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Instruments

THE MAGAZINE OF Measurement and Control

Vol. 18
MAY
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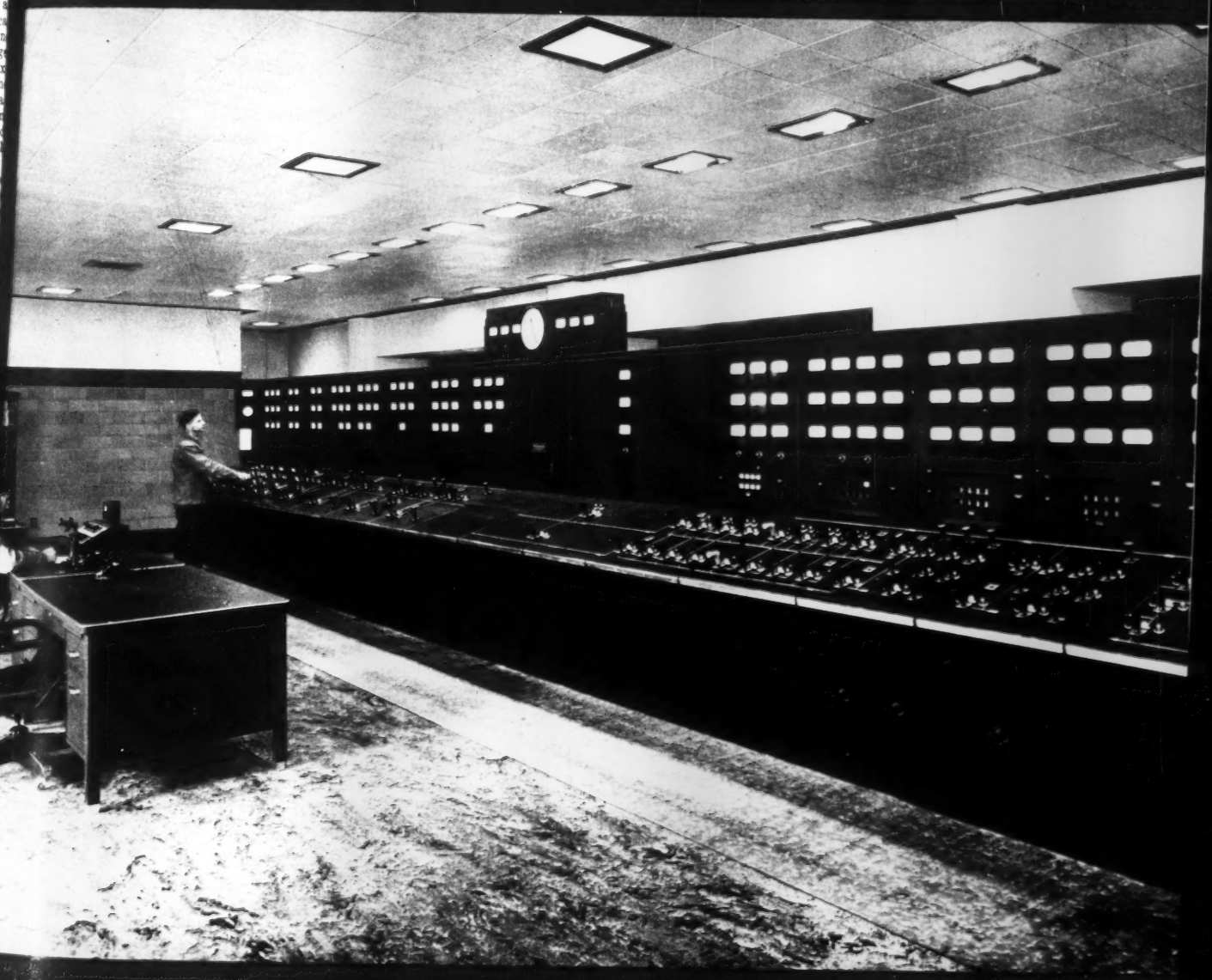
No. 5



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TEST	PRODUCTS	A.S.T.M. Method	U. S. Gov't Method	TAG Manual Test No.	APPARATUS
Acid Heat	Gasoline	D481-39		39	TAG A.S.T.M. Acid Heat Apparatus
Burning	Kerosine	D187-39	210.62	23	TAG Saybolt Lamp & Rather Burning Test Gage
Carbon Residue	Gas, Fuel, Lubricating and Cylinder Oils	D189-41 D524-41T	500.13	14 14A	TAG A.S.T.M. Carbon Residue Apparatus (Conradson) TAG A.S.T.M. Carbon Residue Apparatus (Ramsbottom)
Cloud & Pour	Kerosine, Lubricating, Cylinder and Fuel Oils	D97-39	20.15	13	TAG A.S.T.M. Cloud & Pour Apparatus
Color	Gasoline, Kerosine Petrolatums, Cylinder & Lubricating Oils	D156-38 D155-39T	10.12 10.22	2 3 4	TAG Saybolt Chromometer & Daylight Illuminator *TAG Robinson Colorimeter & Daylight Illuminator TAG Union Colorimeter
Consistency	Grease, Petrolatum	D217-38T	31.11	38	TAG A.S.T.M. Penetrometer, Grease Worker and Cone
Corrosion & Sulfur	Gasoline "	 D130-30	530.11 530.23	 21	TAG A.S.T.M. Corrosion Test Dish Copper Strips
Dilution	Crank Case Oil	D322-35		19	TAG A.S.T.M. Crank Case Oil Dilution Apparatus
Distillation	Gasoline, Kerosine Natural Gas Gas Oil Crude Oil	D86-40 D216-40 D158-41 D285-41	100.14	7 8 8A	TAG A.S.T.M. Distillation Apparatus
Ductility	Bituminous Materials	D113-39		37	TAG A.S.T.M. Ductility Mold
Emulsification	Lubricating Oil	D157-36	320.6 320.32	28	TAG A.S.T.M. Steam Emulsion Tester TAG Herschel Emulsification Apparatus
Flash & Fire	Kerosine Lubricating Oil Fuel Oil	D56-36 D92-33 D93-40	100.11 110.33 110.22	11 10 9	TAG A.S.T.M. Closed Tester TAG A.S.T.M. Cleveland Open Cup TAG A.S.T.M. Pensky Martens
Float	Bituminous Materials	D139-27		35	TAG A.S.T.M. Float Test Apparatus
Gravity	Naphtha Motor Gasoline Natural Gasoline Kerosine Lubricating Oil (Motor) Cylinder Oil Fuel Oil Road Oil Crude Oil	D287-39 D287-39 D287-39 D287-39 D287-39 D287-39 D287-39 D287-39 D287-39	40.1 40.1 40.1 40.1 40.1 40.1 40.1 40.1 40.1	1 1 1 1 1 1 1 1 1	TAG A.P.I. Hydrometer, Range 48 to 55° TAG A.P.I. Hydrometer, Range 55 to 70° TAG A.P.I. Hydrometer, Range 65 to 90° TAG A.P.I. Hydrometer, Range 40 to 50° TAG A.P.I. Hydrometer, Range 20 to 35° TAG A.P.I. Hydrometer, Range 20 to 30° TAG A.P.I. Hydrometer, Range 5 to 35° TAG A.P.I. Hydrometer, Range 10 to 25° TAG A.P.I. Hydrometer, Range 10 to 50°
Gum Content	Gasoline	D381-36	330.2	15	TAG A.S.T.M. Preformed Gum Apparatus
Gum Stability	Gasoline	D525-41T		15B	TAG A.S.T.M. Gum Stability Apparatus
Loss on Heating	Petroleum Oils and Asphaltic Compounds	D6-39T			TAG A.S.T.M. Loss on Heating Apparatus
Melting Point	Paraffin Wax Petrolatum	D87-37 D127-30	140.1	31 34	TAG A.S.T.M. Paraffin Wax M.P. Apparatus TAG A.S.T.M. Petrolatum M.P. Apparatus
Penetration	Bituminous Materials	D5-25		36	TAG A.S.T.M. Penetrometer
Precipitation Number	Lubricating Oil	D91-40	310.11		TAG A.S.T.M. Centrifuges
Sampling & Gaging	All Petroleum Oils	D270-33			TAG A.S.T.M. Sampling Thieves and Thermometers
Sediment	Fuel Oil	D473-38T	300.2	40	TAG A.S.T.M. Sediment Apparatus (Extraction Method)
Softening Point	Bituminous Materials	D36-26		32	TAG A.S.T.M. Ring and Ball Tester
Sulfur	Kerosine, Naphtha	D90-41T	520.12	20	TAG A.S.T.M. Sulfur Determination Apparatus (Lamp Method)
Vapor Pressure	Motor & Aviation Gasoline & Natural Gas	D323-41	120.1	22	TAG A.S.T.M. Reid Bomb
Viscosity	Gasoline, Kerosine Gas, Lubricating, Cylinder, Fuel and Road Oils, Petrolatum and Liquid Petroleum Products	 D88-38 D445-39T	 30.43	6 5 5A	*TAG Saybolt Thermo-Viscometer TAG A.S.T.M. Saybolt Universal & Furol Viscosimeter TAG A.S.T.M. Kinematic Viscosimeter
Water by Distillation	Lubricating, Cylinder, Fuel, Road and Crude Oils	D95-40	300.13	16	TAG A.S.T.M. Water Determination Apparatus
Water and Sediment	Fuel and Crude Oils	D96-40	300.32	17	TAG A.S.T.M. Centrifuges

See TAG Oil Testing Instrument Catalog No. 699 for information concerning the apparatus listed in this table.
*Not official, but widely used for this test.

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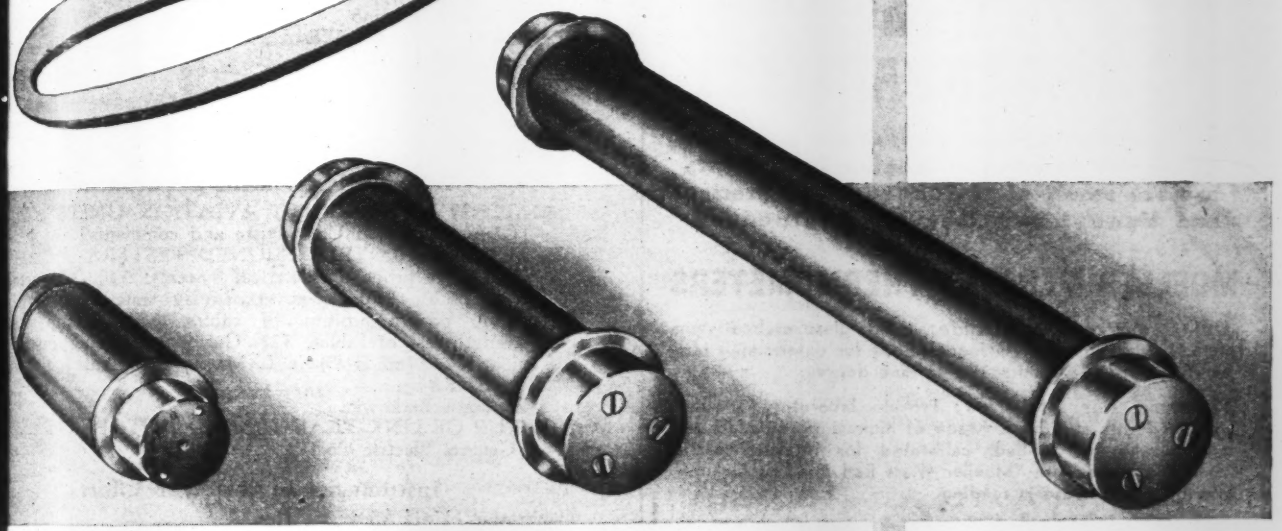

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

An Open Letter to Messrs. Green and Murray:

It will take labor STATESMANSHIP to settle, for the good of all, the questions raised in the letter which follows. Here is why:

When a great scientist builds an instrument that will benefit mankind, no delegate invades his laboratory and asks him to take out union cards to do welding, machining, wiring, etc. If he moved to a plant, the unions would no doubt allow HIM to weld, machine, wire, etc., because HE is a great physicist. He would not be told "Your brain is affiliated with the American Physical Society but your hands must pay dues to labor unions before they may use tools."

Instrumentation is a physical science. A plant instrument department is "one famous physicist multiplied": its joint "know-how" surpasses that of one scientist; its joint work is professional; its members should be allowed to do ANY instrument work. Do you not agree with this view?—M. F. BEHAR, *Editor*

[Personal letter published by permission of the writer, who heads an Instrument Department.]

Dear Major Behar:

Do you have any information on duties of industrial plant instrument men? I am particularly interested in craft boundary lines.

This request is brought about by the fact that we have in our instrument shop a 9" engine lathe, with attachments, which is used in various ways in connection with the installation, operation and maintenance of control equipment of the instrument type. On this lathe we make new parts, special items for laboratory equipment, screws and fittings. Sometimes it involves thread-cutting, boring or perhaps just a polish job with crocus cloth.

Now comes the problem. A grievance has been filed with the plant management by the machinist group. They want the lathe removed from the instrument shop.

The outcome will probably be based on the answer to the question—"Is it general practice for an instrument shop to have and use an engine lathe?"

Any help you can give will certainly be appreciated, for as a craft we are young and, as a result, we must go through the establishing of "Boundary lines." Other similar problems are already on the horizon in connection with piping, tubing and using an oxy-acetylene torch on work.

In our case, we work with metering (flow, temperature, pressure, etc.), gaging and control equipment. We install new equipment and service and maintain the various items.

We install by-pass manifolds on orifice meters and the supporting brackets or stands. In most cases, the lines from orifice to meter are ½" pipe and we have the pipe-men install them.

Motor valves are inspected and adjusted or repaired and also repacked by our group. The main reason for this is that the man who works on the controller thus knows the condition of his valve and, therefore, is able to get better results from the control equipment. It also prevents "passing the buck" as to whose part of the equipment is at fault.

Potentiometers and resistance thermometers are placed in panels and connected by our group. The lead wires and conduit are installed by the electricians. Thermocouples, etc., and care of the equipment are part of the instrument-man's work. We use oxy-acetylene to fuse our couples, and also use carbon arc.

Occasionally we have a broken part to repair by brazing. Welding is done on only very small items, but in most cases is taken to the welders. We do use our oxy-acetylene torch for silver soldering and also on soft-soldering jobs such as installing new Bourdon tubes on gage sockets. If a pipe thread is broken off a socket, we have welders build it up; then the machinists do the re-threading.

Our air lines, to the controller and to the controlled items, are all tubing. If the items are within 100 feet of each other, we run the tubing; if farther, we have it run by the pipe-men.

We have electric transmitters and receivers on flow lines, but these are also cared for by the instrument men.

At the same time, on a cycle control unit in this plant, there are valves that we have left alone. This is because the valves are actuated by an elaborate GE control unit and positioned by a three-horsepower motor. This, we feel, places them in the electricians' territory. On the other hand, we have solenoid valves that we maintain.

In connection with safety, based on explosive vapors that are at times near the equipment, we do not attach or remove any instrument wires that are on 110-volt lines.

Our work covers products of all the leading and some of the other makers of control equipment: Hanlon-Waters, Morey-Jones, Cochrane, Tagliabue, Brown, Taylor, L & N, Foxboro, Bristol, Infilco, Republic, Ashcroft, Barbour-Stockwell, Fisher-Porter, Crosby, Star Brass, Lonergan, Mason-Neilan, Weston, etc., etc.

Is there any protection against the older and organized crafts for the Instrument Man? Is he going to get squeezed out by the other groups? On contract jobs (closed shop) for industrial process plants, I believe that instruments are now being installed by members of the Pipe Fitters Union. Yet trouble always seems to come along when the instrument has "wires" on it.

Is it true that in the Akron district the instrument man can only *ask a pipe-fitter* to take a screwdriver and make an adjustment to an instrument?

Are there any existing agreements between the "old line" organizations that recognize the Instrument Man as one doing work similar to that listed in previous paragraphs?

In other words, we have societies and associations, but do we have a *Craft* Organization? If we are to continue to exist, we need to form one or to get into an existing group that has a knowledge of our work and labor problems.

Yes, at times an instrument man does "border-line" jobs, but in the long run aren't instruments creating jobs for other crafts beside ours?

Your counsel will be valued and any leads on practices in other areas greatly appreciated.

[NAME WITHHELD]

THANK YOU! I take this means of thanking all those who have been easing my tasks since April 9 when my health broke. Since then, neuritis, partial paralysis and other ailments have confined me to my home (245 Melwood Street, Pittsburgh 13, Pa.). Greatest credit is due my wife, thanks to whose experience as secretary and office manager our home has been the editorial office, relieving *Instruments'* office of editorial-department clerical work and enabling me to do as much *Instruments* work as usual with less effort than usual. To her and all you others, *thank you!!*—MFB

Group Photograph Taken Shortly After Opening of Conference (before Arrival of Delegation from Appalachian Instrument Society)

First Row left to right: Rieger, Ferguson, Kayan, Roberts, Maienshein.

Second Row left to right: Webb, Shafer, Fairchild, Sperry, Exline, Pigott, Darnell, McNamee, Prince, Rimbach, Sachse.

Standing left to right:
Sonntag, Gambrill, Susany, Mahaffay, Revell, Flikkema, Moore, White, Wildhack, Barnum, Baker, Bruns, Worthing, Irwin, Dewey, Getting.

The Instrument Society of America Becomes a Reality

By RICHARD F. ROBERTS, Chairman Publicity Committee I.S.A.
136 Cleveland St., Orange, N. J.

The third meeting of the Conference for the Formation of a National Instrument Society was held in Pittsburgh Saturday April 28th, 1945. Fifteen (15) Societies were represented by delegates, alternates, members, and guests, from the Societies located at—

Baltimore
Charleston (W. Va.)
Chicago
Cleveland
Detroit
Kansas City (by proxy)
Los Angeles
New Jersey
New York City
Northern Indiana (by proxy)
Philadelphia
Pittsburgh
Tennessee ("Appalachian")
Washington (D. C.)
Wayne County (Mich.)

Mr. R. J. S. Pigott, President of the American Society for Measurement and Control (Pittsburgh) presided as Chairman; and the first order of business was to formulate the basis upon which a National Society could be organized.

Constitution Begins to Take Shape

Reference was made to the "Declaration of Policy" as shown on page 288 of *Instruments* for April 1945, and the following portions were voted on by the delegates and approved as noted:

(a) Article I—The name "THE INSTRUMENT SOCIETY OF AMERICA" was approved.

(b) Article II—All three paragraphs relative to "Government" were approved.

(c) Article III—Approval was given only to the following portion relative to "Objectives": "The objectives of the Society shall be to advance the arts and sciences connected with the theory, design, manufacture and use of instruments in the various sciences and technologies."

(d) Article V—Paragraph 2 relative to qualifications for membership was approved.

(e) Article VII—Paragraph 1 relative to the four officers only was approved.

(f) Article IX—All three paragraphs covering "Board of Directors" were approved.

Following discussion by delegates, the following were voted upon and approved:—

1. Society Officers (per Article VII above) are to be elected by letter ballot from the entire Society membership, and that such regular officers (except Secretary) shall not succeed themselves. Nominations to include two names for each office.

2. The Finance and Constitution Committees should work together on the subject of dues.

3. The Constitution Committee should create three grades of membership, as follows:—Honorary Member—Member—Student Member.

4. The *pro tem* officers (to be elected today) are to handle the Society affairs until a regular election can be held following preparation of a Constitution and By-Laws and the ratification of same by the local Societies; but this must be effected by March 1st 1946. In the event that ten (10) local Societies have not ratified the new Constitution within such time limit, another general meeting is to be called.

Society Officially Created by Unanimous Vote

Chairman Pigott then proceeded to poll the delegates. Upon receiving assurances that all had the power to act for their respective Societies, a vote was taken relative to the formation of a National Society. By unanimous vote "THE INSTRUMENT SOCIETY OF AMERICA" was created. Everybody then adjourned for lunch.

Behar Given Ovation

During lunch Major M. F. Behar was honored by a rising vote of thanks of all those present for the many years he has devoted to the instrument movement which now has culminated in the formation of a national society. Major Behar expressed regret that owing to illness it was not possible for him to take part in the deliberations. He traced the development of the national society idea, outlined the various fields in which this and other national societies could work: industrial, scientific, educational, etc., and recommended that those present—mostly department heads and other successful men—see to it that this Society be devoted to the welfare

nd advancement of younger and less experienced men.

Nominations and Elections of Officers

Upon convening the afternoon session, Chairman Pigott called for nominations for officers, each to be nominated and elected separately. The election results are as follows:

President—Mr. Albert F. Sperry
Vice-President—Prof. Carl Kayan
Treasurer—Mr. Clarke E. Fry
Secretary—Mr. Richard Rimbach

The office of the secretary was designated as the temporary office of THE INSTRUMENT SOCIETY OF AMERICA and is located at 1117 Wolfendale St., Pittsburgh 12, Pa.

Other Decisions

Following the election of officers, Mr. Pigott turned over the chair to the new *pro tem* President, Mr. A. F. Sperry. Various matters were then discussed, and the following decisions were then voted on and approved by the delegates:

(a) All existing constitutions and by-laws of local societies shall remain in force until the National Society constitution and by-laws are ratified, at which time all such local constitutions and by-laws will be considered as void.

(b) The new Constitution Committee is to give full consideration to the needs of the local societies.

(c) The local Societies will be referred to as "Sections" of the National Society, *viz.* "The Instrument Society of America (Pittsburgh Section)."

(d) *If* it *is* found possible to proceed with the proposed "Exhibit and Conference" to be held in Pittsburgh, from Sept. 17th to 21st 1945,—then the National Society agrees to sponsor such exhibit,—also such expense as paid out by the New York, Chicago, and Pittsburgh Societies incidental to the holding of the three Inter-Society meetings, shall be refunded to such Societies out of the "Exhibit" profits.

Committees Appointed

President Sperry then proceeded to appoint the following committees, with duties outlined:—

Constitution—M. H. White (Philadelphia) *Chairman*, H. F. Moore (N. J.), A. H. Shafer (Pittsburgh).

Exhibit—P. Exline (Pittsburgh) *Chairman*, M. S. Jacobs, F. Havrilla, Roy Bailey, R. Rimbach, F. McGough.

Finance—H. E. Ferguson (Chicago) *Chairman*, R. C. Darnell (Washington), H. H. Barnum (Detroit), also C. E. Fry, Treasurer, *ex-officio*.

Membership—C. O. Fairchild (N. Y.) *Chairman*, J. F. Maienschein (Baltimore), B. F. McNamee (Los Angeles), W. A. Reichow (Kansas City).

Nominating—R. D. Webb (Charleston) *Chairman*, E. C. Rieger (Chicago), W. E. Sachse (Cleveland), J. E. Gambrill (Philadelphia).

Program—R. C. Darnell (Washington) *Chairman*, M. Getting (Pittsburgh), W. E. Mahaffay (Chicago), William Warren (Los Angeles).

Publications—W. A. Wildhack (Washington) *Chairman*, H. L. Jancke (Tennessee), M. F. Behar (Pittsburgh).

Publicity—R. F. Roberts (N. J.) *Chairman*, D. Dickey (Chicago), L. A. Bruns (Baltimore), Charles Holz (Charleston), M. A. Schreiner (Northern Indiana).

Upon completion of the *pro tem* organization, President Sperry called for a motion to adjourn, but all were in favor of further discussion, so a recess was taken until 7:00 p.m. Congenial small groups then went off in different directions, for cocktails and dinner. Everybody expressed appreciation for the cordial hospitality extended by the Pittsburgh society, the meeting arrangements, the get-together luncheon, and the group photograph. It was regretted that Major Behar could not attend the entire conference, as we remembered the inspiring ideas expressed by him at the first conference in New York last December.

First Regular Meeting

This after-dinner session was a sociable affair, delayed in starting until 7:30 p.m., owing to the relaxed condition of many delegates, and those who had Boston cream pie in the Coffee Shop. Mr. Clarke Fry had been notified of his election as Treasurer, and he came to this meeting to meet the delegates and other visitors, informing all that he will shortly send out the bills for the $10.00 charter membership fee, and will be glad to receive any monies that are sent to him. Discussion proceeded as to committee functions, and many helpful details were developed.

The meeting adjourned officially at 9:00 p.m., to enable some delegates to start homeward, but some enthusiastic delegates gathered together on Sunday to talk over more details of committee work.

ATTENDANCE AT THE THIRD INTERSOCIETY CONFERENCE

SOCIETY	DELEGATES	ALTERNATES
Baltimore Industrial Instrumentation Society	Lawrence A. Bruns	B. M. Dewey, J. F. Maienshein
Charlestown Instrument Society	Ralph Webb	
Chicago Society for Measurement and Control	Wm. E. Mahaffay	Hugh E. Ferguson, Earl C. Rieger
Cleveland Instrumentation Society	W. E. Sachse	
Instrument Society of Detroit	H. H. Barnum	
Kansas City Industrial Instrumentation Society	A. Shafer (proxy)	
California Instrument Society	B. F. McNamee	
Society for Measurement and Control (New Jersey)	Harry Moore	R. F. Roberts
New York Society for Measurement and Control	C. O. Fairchild	Carl Kayan
Northern Indiana Society for Measurement and Control	Albert Sperry (proxy)	
Philadelphia Society for Instrumentation	M. H. White	J. E. Gambrill
American Society for Measurement and Control	A. H. Shafer	Richard Rimbach
Appalachian Instrument Society (Tennessee)	H. L. Jankey	Nelson M. Taylor
Instrument Society of Washington	W. A. Wildhack	Richard Darnell
Instrument Society of Wayne County	W. G. Baker	

Chairman: R. J. S. PIGOTT; Vice Chairman: Paul EXLINE; both of Am. Soc. for Meas. & Control (Pittsburgh). Guests (most of whom were present for brief periods only): Major and Mrs. M. F. Behar, Lester F. Boss, R. E. Flikkema, Clarke E. Fry, Milan Getting, Jr., Chester H. Huffman, Bruce A. Irwin, M. S. Jacobs, S. W. Prince, Frank Revell, Alfred Sonntag, Louis M. Susany, Professor A. G. Worthing.

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ELECTRIC GAGING METHODS
for Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

IX. BRIDGE AND POTENTIOMETER CIRCUITS: GENERAL PRINCIPLES.

§ 1. Classification of Bridge Circuits

For the precise measurement of impedance, there is no satisfactory substitute for the bridge circuit, in which the unknown circuit element is compared to a standard having accurately-known characteristics. With such circuits it is possible to measure capacitances, inductances, or resistances—or combinations of two or more of these parameters—to a high order of accuracy. In a null method the accuracy obtainable is limited only by the accuracy (and the purity) of the comparison standards employed and by the sensitivity of the indicating or detecting instrument. In a deflection method (which must be used for dynamic measurements) the indicating device must be capable of being calibrated, and its response characteristics affect the accuracy of the measurements. This is not true of the null method, in which the detecting device has no function other than to indicate balance of the circuit; no special requirements other than sensitivity need be imposed on the detector.

In electrical measurements it often is necessary to make accurate determinations of capacitance, inductance, and ohmic resistance of circuit elements. Reactance bridge circuits—those used to measure capacitance or inductance—must be excited with alternating current; the physical effect of reactance is to shift the phase of the current flowing with respect to the exciting potential.* This requires that the bridge circuit be capable of being balanced for the several parameters, and it usually is necessary that the balance adjustments be made separately. It is convenient if each adjustment is independent of the others.

In gaging practice a different condition obtains: it is customary to construct primary elements in such a manner as to permit one parameter only to be varied by the unknown magnitude. Thus the circuit is employed to measure changes in one parameter only. It often is necessary to make initial adjustments—at the time of installation—for the other circuit parameters; once made, these adjustments are permanent. There are certain exceptions; conditions of installation may require an occasional adjustment of the bridge circuit to maintain an operating condition.

In general, therefore, the bridge circuit used in electric gaging practice is one sensitive to changes in one parameter only, although provision must be made for initial balance for the other two. Descriptions of specific bridge circuits will be made on this basis.

The bridge circuits most employed in gaging practice may be classified in this manner:

(1) *Variable-capacitance* gaging circuits:

(a) Containing variable capacitive elements, fixed capacitive elements, and fixed resistive elements.

(b) Containing variable capacitive elements, fixed mutual-inductance elements, and fixed resistive elements.

(c) Containing variable capacitive elements and both fixed and variable resistive elements.

(2) *Variable-inductance* gaging circuits:

(a) Containing variable self-inductance elements, fixed self-inductance elements, and fixed resistive elements.

(b) Containing variable self-inductance elements, fixed mutual-inductance elements, and fixed resistive elements.

(c) Containing variable self-inductance elements, and both variable and fixed resistive elements.

(d) Containing variable mutual-inductance elements, fixed mutual-inductance elements, and fixed or variable resistive elements.

(3) *Variable-resistance* gaging circuits:

(a) Containing variable and fixed resistive elements.

(b) Containing variable and fixed resistive elements, and variable and fixed capacitative elements.

It should be noted that this listing is less complete than that given in an earlier chapter. To it, however, must be added

(4) *Frequency-sensitive* bridge circuits:

(a) Containing resistive and capacitive elements.

(b) Containing resistive, inductive, and capacitive elements.

The most convenient operation is obtained when the bridge circuit is symmetrical both electrically and mechanically. This symmetry is ordinarily achieved by placing in two adjacent arms of the bridge circuit the working gage and the reference gage respectively, or by placing the two variable-impedance elements of a ratio-type gage in the same manner. Such symmetrical bridge circuits are known as ratio-arm bridge circuits.* Not all bridge circuits used in electric gaging applications are of the symmetrical forms; for example, the frequency-sensitive bridge circuits are not, and the Schering circuit, which is one of the most sensitive to small capacitance values, is not symmetrical. But the asymmetrical circuits are less easily used, and are in general more sensitive to disturbance.

Most gaging circuits are excited by alternating current. Inductive and capacitive elements must be so excited, and when amplification is required it is convenient to employ a-c. excitation even with resistive elements. Thus, the effect of stray capacitance in a gage circuit employing resistive elements may be quite appreciable. It is necessary in practice to make available some facility for capacity balance of the circuit.

§ 2. Potentiometers

For the precise measurement of potential, the potentiometer method is the most precise available. As with the bridge circuits for measuring impedance, the measurement is made by comparing the unknown to a standard, with the detector employed to indicate the quality of adjustment of the circuit. The accuracy of the measurement depends upon the accuracy of the standard and the sensitivity of the detector. The method may be used to measure either direct or alternating currents or potentials.

When the potentiometer method is used to measure steady potentials, the measurement is one of magnitude only; there is no question of phase position. Polarity must be observed, of course, but this is accomplished simply by making the proper connections in the circuit. But when alternating potentials are to be measured, the relative phase of the standard and the unknown potentials must be considered. There are two general types of a-c. potentiometers: those which measure the resultant potential in magnitude and phase (polar potentiometers), and those which measure the two components separately (coördinate potentiometers).

The stable and accurate amplifiers which have been developed within the last decade have to a large extent replaced the a-c. potentiometer; today there is little application of this instrument in gaging practice. The d-c. potentiometer, however, has retained its place because of its

*Pure capacitance causes the current to lead the voltage by 90°; pure inductance causes the current to lag 90° behind the exciting voltage. Two potentials or currents differing in phase by 90° are said to be in quadrature.

*The ratio-arm bridge circuit is that form in which the standard and the unknown are placed in *adjacent* arms of the circuit; the product-arm form is that in which the standard and the unknown are placed in *opposite* arms. This terminology has had a limited use in the literature.

This instalment of H. C. Roberts' serial constitutes one of the most valuable references on a-c. bridge circuits ever printed anywhere. Owing to the paper shortage, single copies of *Instruments* are not sold and back copies cannot be furnished.—MFB

extremely high accuracy, relative simplicity of construction, and reliability over long periods of time. The instrument is available in a number of different forms, manually and automatically operated, indicating or recording.

The deflection method can be employed with potentiometer circuits, just as with bridge circuits. The indicating or recording instrument must then be calibrated and must maintain its calibration. Much of the accuracy possible with the potentiometer method is sacrificed if the deflection method is used.

In any null method, the sole function of the detector or indicating device is the indication of the balance condition of the circuit (although it may be used for other purposes as well) and its primary requirement is for high sensitivity. For convenience, speed, and safety in operation, it is desirable that the detector indicate both magnitude and direction of unbalance, and that the sensitivity of the device be high near the point of exact balance but lower when the unbalance is great.

For use with a deflection method the requirements are somewhat different, and more stringent. Deflection methods are used because of their great speed of operation and their consequent applicability to dynamic measurements. The response characteristics of the instrument are thus of considerable importance.

The necessary characteristics for recording instruments include these items:

(1) Deflection accurately proportional to current (or to potential);

(2) Rate of response sufficiently high to record all frequency components present in the magnitude being measured;

(3) Satisfactory damping;

(4) Good mechanical and electrical stability; and

(5) Ability to produce a legible, permanent record at the highest rate demanded by the measurement.

The most widely employed recording instruments are current-actuated, based upon the principle of the moving-coil galvanometer. In order to provide relatively high frequency response, the actuating currents must be comparatively high—of the order of tens or hundreds of milliamperes. Currents of this magnitude are not negligible compared to the exciting current of the circuits, and therefore the characteristics of the instruments employed will alter the behavior of the bridge (or potentiometer) circuit, and must be considered in the analysis of that circuit. Present practice, however, often employs amplifiers in conjunction with current-actuated galvanometers, and with them the effective impedance of the detector may be made to approach infinity.

Circuits excited with alternating current require special consideration with regard to the indicating or recording instrument. If the instrument is sensitive only to the magnitude of the circuit output, there will be no indication of the direction of the unbalance. While in null methods this may impose only inconvenience in operation, in deflection methods (and particularly in dynamic measurements) the resulting data may be made useless unless some special means of indicating polarity is employed. Electrodynamometer type instruments, d-c. instruments with phase-sensitive rectifiers, or phase-discriminating amplifiers are customarily used to indicate both direction and magnitude of the unbalance of the circuit. Such devices have come to be applied as standard practice in electric gaging applications. A few special forms of a-c. bridge circuits employ rectifier elements in the arms of the bridge circuit itself.

The characteristics of these detectors must also be considered in the analysis of the circuit functioning.

X. BRIDGE CIRCUITS.

§ 1. Mathematical Theory.

There is a basic difference between the methods used to measure resistance and those used to measure inductance or capacitance. In the measurement of resistance values only the ohmic *resistance* of the circuit component need be considered, while in the measurement of inductance or capacitance the *reactance* is the magnitude of primary interest. Ohmic resistance is always present, however, although its relative value may be quite small. The combined effect of resistance and reactance is termed *impedance*; mathematically it is their vector sum.

Reactance in a circuit produces two effects: it limits the amount of current which can flow, and it changes the phase of that current with respect to its exciting potential. In a circuit containing only pure reactance, there is a difference in phase of 90° between voltage and current—capacitive reactance causes the current to lead, while inductive reactance causes the current to lag behind the voltage.

The magnitude of an ohmic resistance does not change if the frequency of the current flowing is changed, but the reactance of an inductive or a capacitive element does vary with frequency. Any capacitance of fixed magnitude represents a reactance decreasing in magnitude with increasing frequency; an inductance represents a reactance increasing with increasing frequency. In bridge circuits excited by alternating current, therefore, the frequency of excitation must be considered when reactive elements are present.

Since the condition for perfect balance of a bridge circuit is that no current shall flow at any time during the cycle through the indicating instrument, it is clear that balance cannot be attained if a difference of phase exists between the two sides of the circuit. It is essential, therefore, to provide both magnitude and phase balances.

To facilitate the establishing of a simple and satisfactory method for computing both the impedance of circuit elements and the phase shift caused by their reactive components, two new terms will here be introduced. They are these: the operator j, which describes the change in phase caused by reactance, and the *impedance operator*, which describes both the impedance and the phase shift of a circuit element.

The operator j merely indicates the operation of rotating a vector through an angle of 90°, or of shifting the phase of a current (with respect to the voltage in the circuit) by 90°. In the manipulation of algebraic expressions involving j, the effect of its operation may be reproduced by multiplying by $\sqrt{-1}$. It should be noted that this is simply a mathematical expedient. Terms including the operator j are described as *imaginary*.

The *impedance operator* is a term which has been devised to simplify alternating current calculations; it contains quantities which describe both the impedance and the phase angle of the circuit element to which it refers. The value of the impedance operator lies in this fact: any result proved for direct current can be applied to alternating currents if impedance operators are substituted for resistance values and if vector symbols are used in place of scalar symbols.

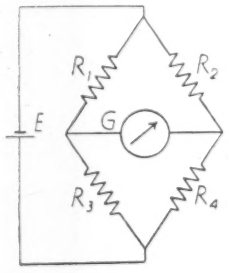
With these two terms, therefore, it is possible to take the simple Wheatstone bridge network as a basic form, and modify it by inserting reactive elements as desired. It is then necessary to replace the resistive terms in the Wheatstone balance equation by the appropriate impedance operators and simplify; the result is the balance equation for the reactive network. Most of the a-c. bridge circuits in use are derived from the four-arm Wheatstone resistance bridge circuit.

For convenience, in the following descriptions the numerical subscripts used in all networks to be described will refer to the position in the circuit, no matter what form of circuit element they may pertain to; the subscript *1* will refer to the upper left branch in the diagram, the subscript *2* to the upper right branch, etc. In the table of Fig. 136 the impedance operators describing the simple combinations of circuit elements most used are tabulated. Thus, to learn the effect of replacing a resistive element with a reactive ele-

FIG. 136 TABLE OF IMPEDANCE OPERATORS.

SYMBOL	OPERATOR
R	R
C	$-j/\omega C$
L	$j\omega L$
L C	$j\omega L - j/\omega C$
L R	$j\omega L + R$
R C	$R - j/\omega C$
R C	$\frac{R(1-j\omega CR)}{1+\omega^2C^2R^2}$
L R C	$\frac{R+j\omega\left[L\left(1-\omega^2CL\right)-CR^2\right]}{\left(1-\omega^2CL\right)^2+\omega^2C^2R^2}$
L R R	$\frac{R_1\left\{\left[R_1\left(R_1+R_2\right)+\omega^2L^2\right]+j\omega LR_2\right\}}{\left(R_1+R_2\right)^2+\omega^2L^2}$

ment, the diagram of Fig. 137 is consulted, and in the accompanying balance equations the appropriate impedance



$$\frac{R_1}{R_2} = \frac{R_3}{R_4};\quad R_4 = \frac{R_2R_3}{R_1}$$

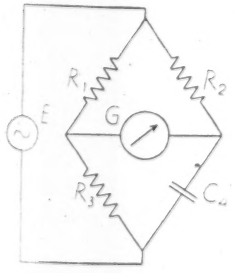
FIG. 137

operator is substituted. Reduction is carried out by the ordinary algebraic methods, with the real and the imaginary terms separately collected and equated where necessary.*

§ 2. BRIDGE CIRCUITS FOR MEASURING CAPACITANCE.

The balance equations given for the simple resistance bridge circuit hold for either direct or alternating current operation, although the sketch indicates d-c. excitation. In the other circuits to be shown it will be understood that the excitation is by alternating current, and that the indicating instrument *G* is sensitive to alternating currents or potentials.

If any one of the four resistive elements in Fig. 137 is replaced by a capacitive element, the diagram and drawing then are changed to these forms—Fig. 138:



$$\frac{R_1}{R_2} = \frac{R_3}{j/\omega C_4};\quad C_4 = \frac{jR_1}{\omega R_2R_3}$$

FIG 138

Clearly a perfect balance for this circuit can never be attained, since the imaginary component cannot be removed. The physical condition is that of a difference in phase between the two sides of the bridge circuit, and one which cannot be removed by any adjustment of the circuit components.

*Any of the standard texts on algebra will provide detailed discussions of these methods. Many of the reactive bridge circuits have been worked out in detail, and rigorous analyses are available—particularly in "Alternating Current Bridge Methods" by Bernard Hague, to which reference has previously been made.

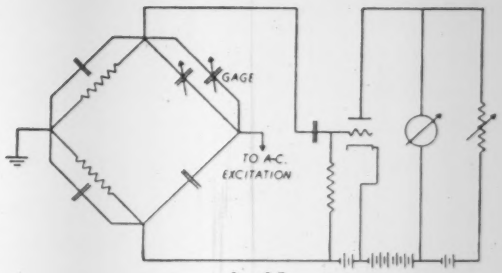


FIG. 27

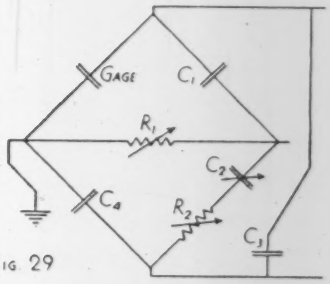
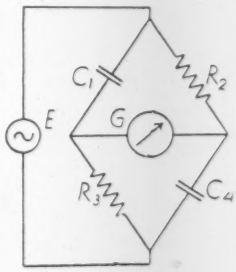


FIG. 29

These diagrams, from the May 1944 instalment of H. C. Roberts' serial, are referred to in this instalment and are reproduced for the convenience of the reader.

When *two* resistances are replaced by capacitances in opposite arms of the circuit, it appears thus:

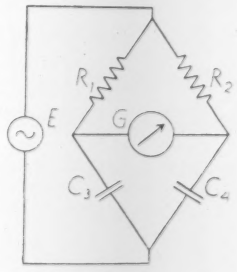


$$\frac{-j/\omega C_1}{R_2} = \frac{R_3}{-j/\omega C_4} \qquad C_4 = \frac{1}{\omega^2R_2R_3C_1}$$

FIG 139

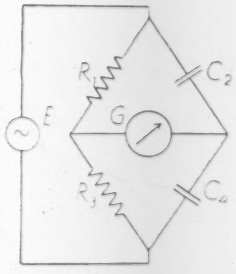
This circuit likewise cannot be balanced.

But if capacitances are placed in adjacent arms of the bridge circuit, in either of these two possible configurations, balance can be attained.



$$\frac{R_1}{R_2} = \frac{-j/\omega C_2}{-j/\omega C_4};\quad C_4 = \frac{R_1C_3}{R_2}$$

FIG 140 A



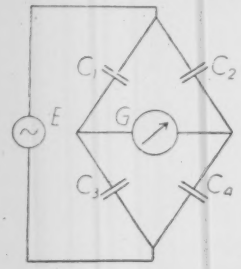
$$\frac{R_1}{-j/\omega C_2} = \frac{R_3}{-j/\omega C_4};\quad C_4 = \frac{R_1C_2}{R_3}$$

FIG 140 B

With either of these two physical arrangements, it is possible to remove the imaginary components by the balancing process. It should be noted, too, that the symbol ω does not

appear in the equation for balance, indicating that these circuits are not sensitive to frequency changes.

It is possible, too, to replace all four resistance arms by capacitance elements, as in Fig. 141:

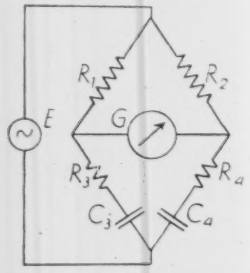


$$\frac{j/\omega C_1}{j/\omega C_2} = \frac{j/\omega C_3}{j/\omega C_4}, \qquad C_4 = \frac{C_2 C_3}{C_1}$$

Fig. 141

Again the balance can be made perfect at any frequency.

If for any reason resistance appears in series with a capacitive element in the bridge circuit, balance can be achieved only by introducing resistance in the adjacent capacitive arm. Thus:



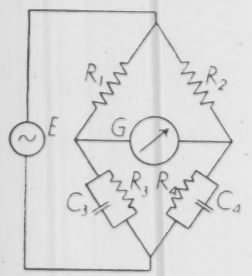
$$\frac{R_1}{R_2} = \frac{R_3 - j/\omega C_3}{R_4 - j/\omega C_4}$$

$$\frac{C_4}{C_3} = \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

Fig. 142

In this circuit, provision must be made for both resistive and capacitive adjustment, and for perfect balance both conditions must be fulfilled simultaneously. Such balancing facility is often required when capacitance-type gaging elements are installed at the ends of long connecting cables, so that the ohmic resistance of the connecting leads is appreciable. One example of such a circuit was given as Fig. 29.

Similarly, if resistance appears in parallel with a capacitive element in the electric circuit, its effect can be balanced by introducing resistance in parallel with the appropriate arm of the circuit, as indicated in Fig. 143:



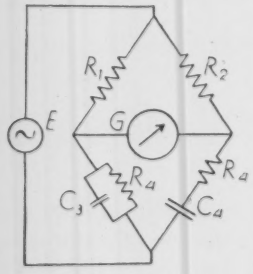
$$\frac{R}{R} = \frac{1/(1/R_3 + j\omega C)}{1/(1/R_4 + j\omega C)}$$

$$\frac{C_4}{C_3} = \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

Fig. 143

Again, the bridge circuit can be balanced at any frequency. Physically these shunt resistances may occur as leakage between conductors of a connecting cable or as leakage between the plates of a capacitive pick-up.

But if a resistance and a capacitance appear in series in one arm, and in the adjacent arm a resistance and a capacitance appear in parallel, the circuit with its equation of balance appears thus:



$$\frac{R_1}{R_2} = \frac{1/R_3 + j\omega C_3}{R_4 + 1/j\omega C_4}$$

$$\frac{C_3}{C_4} = \frac{R_2}{R_1} = \frac{R_4}{R_3}$$

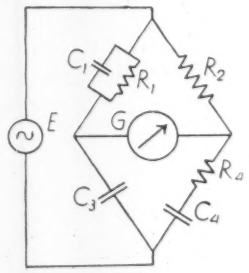
$$C_3 C_4 = 1/\omega^2 R_3 R_4$$

Fig. 144

This bridge circuit is therefore sensitive to frequency; for a specific set of values of resistance and capacitance it can be balanced only at one frequency. Such a circuit can be used to measure impedance values when it is excited by a known frequency; conversely, it may be used as a sensitive device to measure frequency. This particular form is the Wien bridge circuit.

It should be noted that the circuits described before this one are not frequency-sensitive; in their balance equations no term involving frequency appears. They can therefore be used with almost any convenient exciting frequency, and the wave-form of the exciting current need not be pure. When the Wien or other frequency-sensitive bridge circuit is used, however, the exciting current must be of a constant and known frequency, and its wave-form must be good. Distortion in the exciting current is equivalent to excitation by current of more than one frequency, while the circuit can be balanced for one frequency only. If the balance cannot be made perfect, the degree of unbalance remaining may be taken as a measure of the distortion present in the excitation current.

Another non-symmetrical bridge circuit employing resistive and capacitive elements is the Schering bridge circuit. In its simple form this circuit appears as in Fig. 145.



$$\frac{1/(1/R_1 + j\omega C_1)}{R_2} = \frac{1/j\omega C_3}{R_4 + 1/j\omega C_4}$$

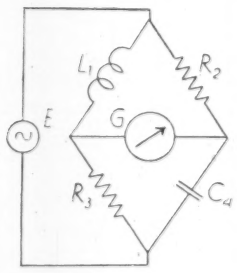
$$R_4 = \frac{C_1}{C_3} R_2 \quad ; \quad C_4 = \frac{R_1}{R_2} C_3$$

Fig. 145

Although it is not symmetrical, this circuit is not frequency-sensitive. It is especially well suited to the measurement of small capacitances, particularly if they show some leakage. It has been successfully used in measurement of mechanical magnitudes with capacitive primary elements. (See Fig. 27.)

Only resistive and capacitive circuit elements have been considered in the circuits so far described. It is informative to consider the condition resulting from the introduction of inductive elements.

From the results already obtained, it may be seen that inductive elements in the bridge circuit must be installed opposite capacitive elements, if the circuit is to be capable of perfect balance. That is, the configuration must be made such that the positive phase shift of one reactive element can be balanced by the negative shift of another. Placing the inductive element in the arm opposite the capacitive element, as in Fig. 146, accomplishes this:



$$\frac{j\omega L_1}{R_2} = \frac{R_3}{-j/\omega C_4}$$

$$C_4 = \frac{R_2 R_3}{L_1}$$

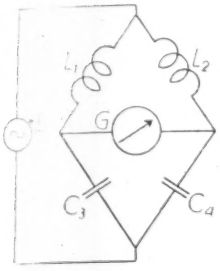
Fig. 146

This circuit can be balanced at any frequency, in theory; in practice some difficulty may be encountered because of inconstant stray capacitances.

In the circuit just given (Fig. 146) both reactive elements are considered as possessing reactance only, and are so shown in both diagram and equations. In the practical case, the resistance of the inductive element is not negligible; indeed, it may even be comparable in magnitude to the reactance. Good quality capacitors usually are nearly pure; their leakage resistance is high and their equivalent series resistance low. Except in the most precise measurements, capaci-

tors with air dielectric may safely be considered as possessing reactance only. From the practical standpoint, therefore, bridge circuits for measuring capacitance are best designed without inductive arms, unless two similar inductive arms are employed; if two such inductive arms, identical in both inductance and resistance values, are used, it is not necessary to introduce other adjustments to take care of the imperfections of the inductive elements.

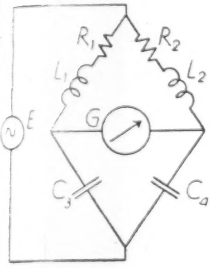
Such a circuit, embodying two arms each containing a mutual inductive element, is shown as Fig. 147A. The same circuit, accepting that the self-inductances are assumed to have some ohmic resistance, is drawn again as Fig. 147B.



$$\frac{j\omega L_1}{j\omega L_2} = \frac{j/\omega C_3}{-j/\omega C_4}$$

$$\frac{C_3}{C_4} = \frac{L_2}{L_1}$$

FIG. 147 A



$$\frac{R_1 + j\omega L_1}{R_2 + j\omega L_2} = \frac{j/\omega C_3}{j/\omega C_4}$$

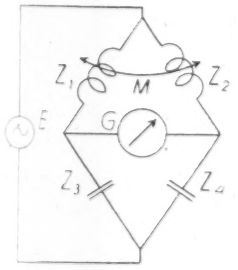
$$\frac{C_3}{C_4} = \frac{L_2}{L_1} = \frac{R_2}{R_1}$$

FIG. 147 B

The balance equations indicate that the presence of resistance in the inductors does not prohibit a balance, so long as the ratio of resistances equals the ratio of inductances. This ratio is not necessarily unity.

In practice, inductive elements are not often used in bridge circuits for measuring small capacitance values. The impedances of capacitive gaging elements is usually high, and it is difficult to arrive at a satisfactory bridge-circuit ratio.

As a special case, the use of ratio arms containing mutual inductance may be considered. Fig. 148 represents the simplest form of bridge circuit containing mutual inductance arms.



$$\frac{Z_1+M}{Z_2+M} = \frac{Z_3}{Z_4}$$

$$\frac{R_1+j\omega(L_1+M)}{R_2+j\omega(L_2+M)} = \frac{-j/\omega C_3}{-j/\omega C_4}$$

$$\frac{C_3}{C_4} = \frac{R_2}{R_1} = \frac{L_1-M}{L_2-M}$$

FIG. 148

In the diagram, the impedances of the arms are indicated by Z_1, Z_2, Z_3, Z_4, and the mutual inductance between the coupled inductive arms by M. A complete analysis of this circuit is beyond the scope of this discussion, but some of its advantages must be pointed out: it provides a compact and stable ratio-arm assembly, somewhat greater sensitivity, and much less disturbance from external causes if the coupling between the mutual-inductance arms is made close.

Many other bridge circuits have been used for measuring capacitances, but those which have been described are representative of the forms used in gaging applications. The requirements in this field are quite specific; they may be listed as follows:

1. The primary element must have one of its electrodes connected to ground (this is a mechanical necessity).

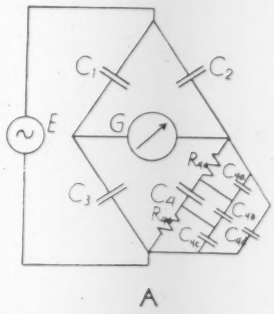
2. The effective capacitance of variable-capacitance primary elements is small (seldom more than 100 mmfd).

3. Ratio-type primary elements are desirable and should be used whenever possible; a ratio-type circuit should always be used.

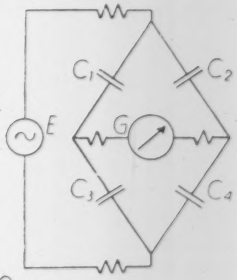
It is convenient that in most instances the resistances occurring in the circuit do not greatly affect the balance; if reasonable care is exercised in construction of the primary elements their leakage resistance will be high, while the series resistances need never be large. The series resistances in general are the resistances of the connecting leads. Perfect balance for the circuit requires that corresponding resistances be introduced in other arms of the circuit. However, since their effect need never be large, gradual or unwanted changes in their values should not introduce large errors even though they are not compensated. But their presence may introduce serious inconvenience in operation.

Proper mechanical placement of the circuit components is essential. If a capacitive primary element is employed in a circuit comprising four equal capacitive elements, best results will be obtained in the same location—at the point of measurement.

To illustrate: if a single variable-capacitance primary element is installed at the point of measurement and connected through a shielded cable to the other component parts of the circuit, the ohmic resistances of the connecting cable will appear in series (and its capacitance in parallel)



A



B

FIG. 149

with the primary element. Actually, then, the circuit is like Fig. 149A. The two resistances R_{4a} and R_{4b} are the ohmic resistances of the connecting cable and have a magnitude of a few ohms. The stray capacitances of the cable (between the two conductors and between each conductor and ground) appear effectively in parallel with the primary element C_4. It is not unusual for these stray capacitances to be greater in magnitude than the gage capacitance. If balance is to be attained, it will be necessary to introduce resistance and capacitance adjustments in another arm of the circuit.

But if all four capacitive circuit arms are placed together at the measuring location, and if this complete bridge circuit is connected through a four-conductor cable to the other portions of the equipment, the situation is simplified. The ohmic resistances are then all external to the bridge circuit and do not enter into the balancing procedure at all. The cable capacitances are still present and of approximately the same value, shunting all four arms of the circuit in nearly equal proportions. This shunt capacitance has the effect of reducing the circuit sensitivity, but does not appreciably impair its accuracy. The effect of the ohmic resistance in the connecting leads may be made negligible in operation. The actual circuit then appears as in Fig. 149B.

In this as in any other high-impedance device, some difficulty will appear when the system is used with long connecting leads, but if the system is made symmetrical in the manner indicated, the experimental difficulties are least. Analysis of a circuit employing a ratio-type element in this manner will show exactly the same improvements, although somewhat smaller because the ratio-type element itself imparts a symmetry into any circuit in which it is installed.

Continued on page 332

Automatic Switching of Shunt Capacitors

By W. H. CUTTINO, Capacitor Engineer, Switchgear Eng'g Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

CAPACITORS have made it possible to supply large increases in load with existing power facilities—an important result in the present war emergency with its shortage of materials and labor. When more and more capacitors are added to a system, however, a situation is reached where their effect becomes objectionable during certain operating conditions. It therefore is desirable to obtain the benefits of additional capacitor correction without the objectionable aspects.

A relatively small capacitor may be connected to a circuit with little effect upon the performance of the circuit. As the size of the capacitor increases, the addition or removal of the capacitor has an increasing effect upon the circuit voltage, line current, line losses and circuit power factor. The line losses are at a minimum when the capacitor kilovars are the same as the load kilovars. The maximum benefits are obtained, therefore, by switching the correct size capacitors at the appropriate time. Because of the large increase in the use of shunt capacitors in recent years, the power systems are rapidly approaching the point where capacitors must be switched automatically in order to obtain the maximum benefits of capacitor correction.

I. Methods of Switching Capacitors

Capacitors may be switched manually with variation in load if a reliable attendant is available to observe the operating conditions such as voltage, kvar, etc., and perform the desired switching operations.

If it is found desirable to switch capacitors with variation in load, consideration should be given to distributing the capacitors out on the circuit and connecting them directly to the motor terminals to be switched OFF and ON with the motor without additional switching equipment. The size of the capacitor switched with the motor switch should be selected to avoid excessive overvoltage due to self-excitation. In some cases it may be desirable to use a separate switch for the capacitor and let the motor control initiate the opening and closing of the capacitor switch.

A time switch may be used to initiate the switching operations in some cases if the load variation follows a repetitive load pattern each week.

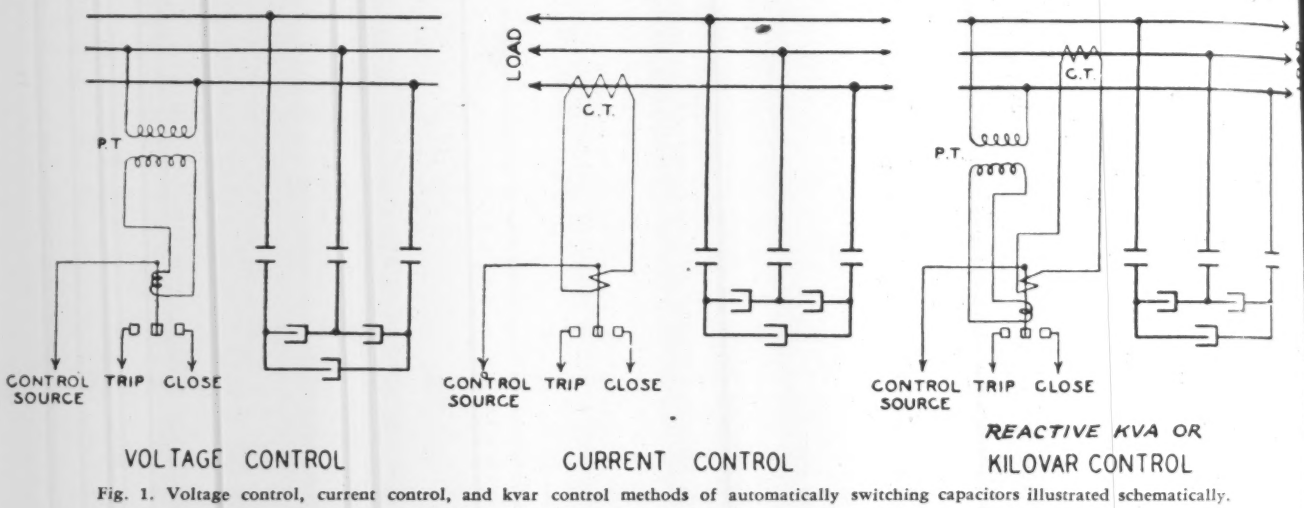


Fig. 1. Voltage control, current control, and kvar control methods of automatically switching capacitors illustrated schematically.

Capacitors may be switched automatically in response to changes in load. The three generally accepted methods of switching capacitors automatically are:

1. Voltage control
2. Current control
3. Kvar control

II. Application of Automatic Control Equipment

The switching of capacitors may be desired to prevent overvoltage, improve voltage regulation, reduce line current, to keep the demand low in proportion to the kilowatt loading or keep the overall power factor within desired limits to maintain minimum cost of power purchased under certain rate schedules.

In deciding whether or not the capacitors should be switched automatically, consideration should be given to the size of the capacitor banks, the extent to which the kilowatt and kilovar load varies over a typical load period, the variation of voltage with load and benefits desired. In making an analysis, it usually is desirable to make measurements of kilovars, kilowatts, and voltage over a typical load period to determine the capacitor kilovar requirements and then, if automatic switching is needed, to determine what type of control would be best suited for actuating the switching device.

When objectionable voltage variations occur with varying loads, the voltage control shown schematically at the left in Fig. 1 should be considered. If the principal reason for switching the capacitors is to avoid overvoltages on lamps and motors during light load periods, the requirements usually can be met by using a single-step voltage control that disconnects the capacitor bank when the voltage rises above a certain value and reconnects it when the voltage falls below a predetermined level.

This single-step voltage control is especially useful in a plant where a number of induction motors are switched off during rest periods or at night. As the motors are shut down, the voltage control disconnects the capacitor bank to keep the voltage from rising too high. As the motors are switched on again, this process is reversed to keep the voltage from falling below normal.

If voltage regulation is the primary objective of the capacitor switching installation, a multi-step voltage control is usually required to hold the circuit voltage within the set limits. The multi-step control is particularly useful on the longer distribution circuits and plant feeders that extend some distance beyond the voltage regulators. Unlike the ordinary voltage regulator, however, the capacitor bank with multi-step voltage control improves the voltage regulation on *both* the supply and the load side of the bank by reducing the current flowing in the supply feeders. This is accomplished without changing the existing regulating equipment and lowers the IX and IR losses in the circuit. If the voltage change produced by the capacitor is greater than the difference between maximum and minimum desired voltage limits, then multi-step voltage control should be used. Fig. 3 illustrates a case where one-half the capacitors produce a voltage change

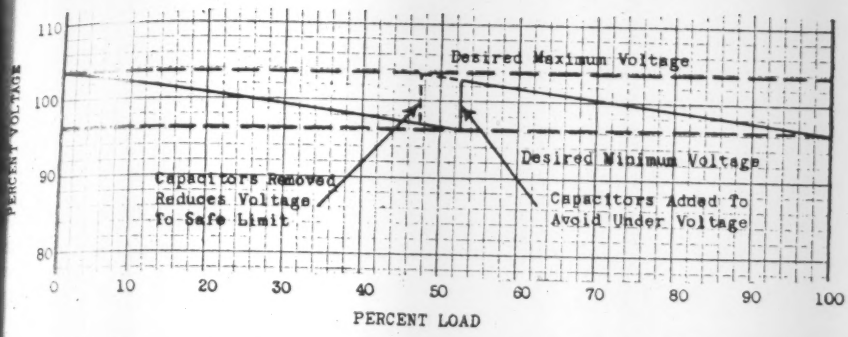


Fig. 2. Graphic illustration of voltage regulation by means of single-step switching in response to changes in circuit voltage.

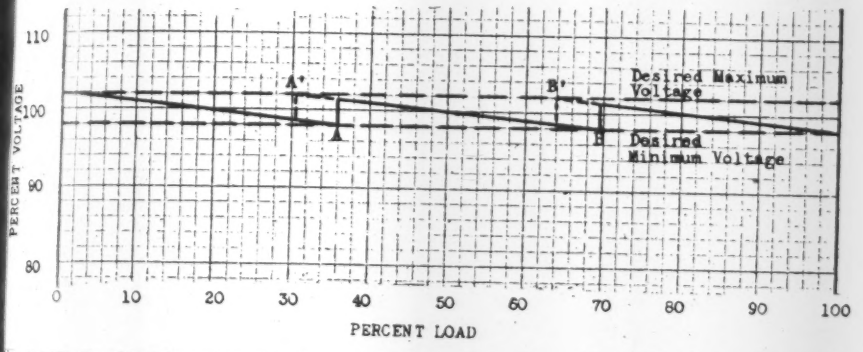


Fig. 3. Graphic illustration of voltage regulation by means of multi-step switching in response to changes in circuit voltage. As load increases, the voltage drops and capacitors are added selectively at A and B to boost voltage. As load drops and voltage rises, the capacitors are removed selectively at B′ and A′ to reduce the voltage.

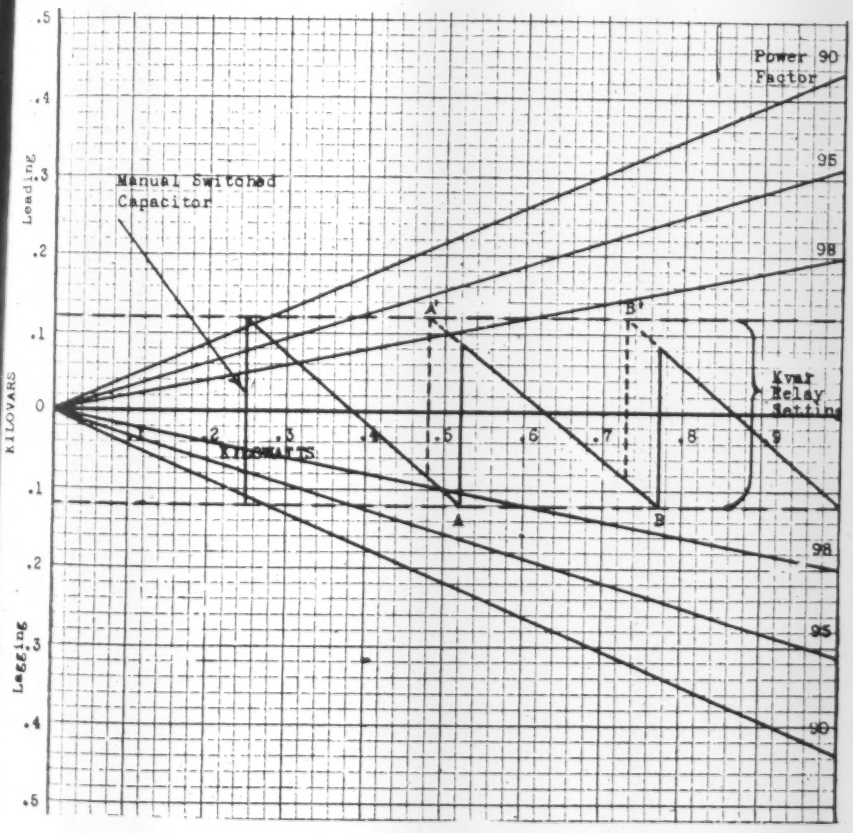


Fig. 4. Graphic illustration of kvar regulation by means of multi-step capacitor switching in response to changes in kilovar load. As load increases, the lagging kilovars increase and capacitors are added selectively at A and B to keep the kvar demand within desired limits. As the load decreases, the lagging kilovar load decreases and capacitors are removed selectively at B′ and A′ to keep the kvar demand within desired limits.

less than the difference between the desired upper and lower voltage limits. For this situation two switched capacitor banks and a two-step voltage control are used to obtain satisfactory voltage regulation.

If the load with which the capacitors are associated is small in comparison with the total load on the circuit, then the addition or removal of the capacitor bank will have little effect on the circuit voltage. In this case the voltage control may cause the capacitors to be switched independently of load. If the capacitors are connected to a well-regulated bus, the voltage regulators or other devices will usually keep the voltage within satisfactory limits independently of the amount of capacitors applied. Circuit voltage therefore does not necessarily reflect the need for capacitors and, if capacitors are to be switched, other methods of detecting their requirements should be used.

For example, if sufficient capacitors are added to supply the lagging kvar at full load it may be desirable to switch them with variations in load to reduce the demand and losses or avoid a penalty because of excessive leading power factor at light load. Sometimes capacitors are installed so that regulating equipment can maintain a satisfactory voltage level at full load. In such cases the capacitors usually should be removed at light load in response to kvar control or current control so that the regulator will be operating under the best conditions to keep the voltage within satisfactory limits.

The choice between current and kvar control depends upon the relationship of load power factor to variation in kilowatt loading, the number of switching steps required and the existing physical circuit arrangement. In cases where either type of control can be used, the physical arrangement of the circuit and the availability and location of instrument transformers will dictate the type of control to be selected. The current control master element should receive its signal from a current transformer located on the load side of the capacitor to measure the uncorrected load, whereas the current transformer for signaling the current element of the kvar relay should be located on the supply side of the capacitor.

Where the voltage is well regulated and the load power factor remains substantially constant with variation in kilowatt loading, the current control scheme shown in the center of Fig. 1 is ordinarily used.

On circuits where the voltage is well regulated and the load power factor varies in an unpredictable manner with variation in kilowatt loading, the kvar control shown in schematic form at the right in Fig. 1 gives the best results.

Fig. 4 illustrates graphically how the kvar demand was kept within desired limits at an industrial plant where it was desired to improve the full-load power factor from 70% to 97% lagging.

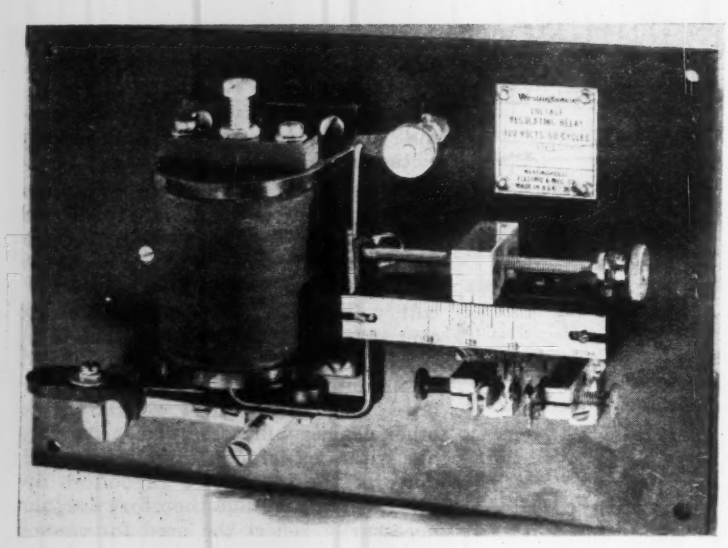


Fig. 5. Voltage regulating relay used for initiating the automatic switching of shunt capacitors in response to change in circuit voltage.

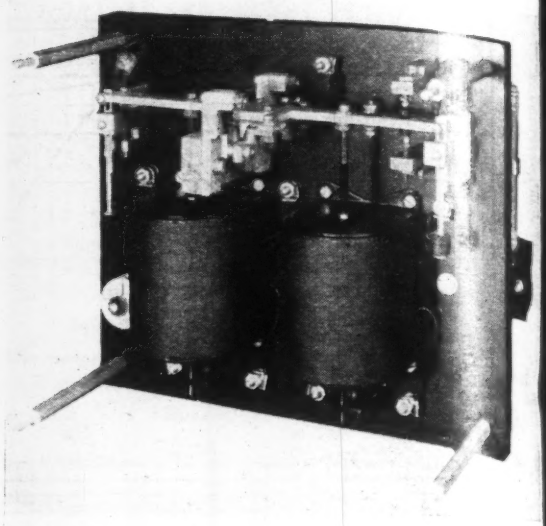


Fig. 6. Kvar regulating relay used for initiating the automatic switching of capacitors in response to change in kvar demand.

In this case the load power factor was expected to vary in an unpredictable manner between 60% and 80% for load variations between ¼ and full load.

By adding sufficient capacitor kilovars to improve the power factor from 70 to 98½% and having about ⅓ fixed with the remaining divided into two steps of about ⅓ each, the kvar demand was kept within desired limits.

III. Necessary Components

The automatically switched capacitor installation consists of the capacitor, the capacitor switch, the automatic control, instrument transformers and control source.

These components can be assembled in combinations that will meet almost any operating requirement. Rack type capacitor units are available for either indoor or outdoor service. The capacitor switch and automatic control may be assembled in the capacitor housing or the capacitor switch and the control may be mounted separately from the capacitor. If it is desirable to have the control elements at some central location, the automatic control assembled in a cabinet can be mounted separately from the capacitor or capacitor switch. This latter arrangement is often used with indoor multiple-unit dust-tight capacitor assemblies and outdoor hanger type capacitor units mounted on poles.

The automatic controller which receives and interprets the signal and acts to perform the desired function consists of a master relay, time relay relays, auxiliary devices and a control switch. A voltage-sensitive relay, or a current-sensitive relay, or a kilovar-sensitive relay, is the master element. It receives and interprets the signal and initiates the switching operations after a time delay sufficient to prevent unnecessary switching operations caused by momentary disturbances on the power circuit. The time delay usually is not critical but in the interest of keeping the transient inrush current to a minimum, enough delay is inserted between the opening and closing of the capacitor switch to permit the discharge devices to drain off a substantial part of the stored energy. Auxiliary relays respond to the request of the master element and time delay relay to close or open the capacitor switch and handle the heavier control currents that should not be handled by the sensitive control relays. The capacitor switches may open and close in response to the master element or they may be opened or closed manually by operation of their control switch.

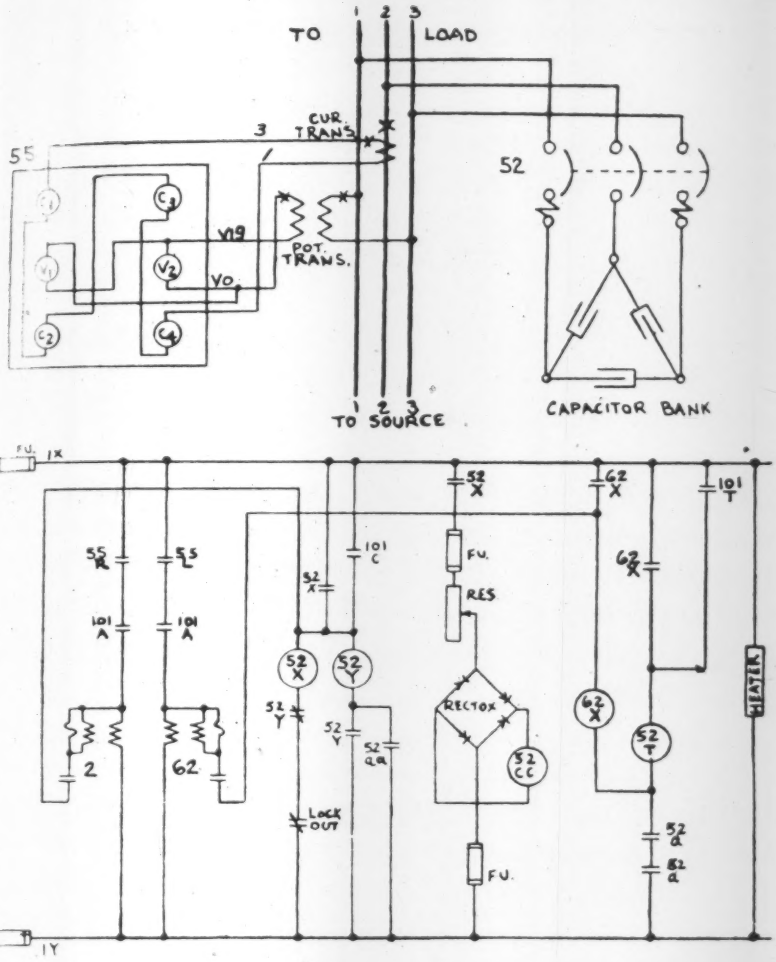
Electrically-operated circuit breakers generally used for switching the larger size capacitor banks have the advantage of providing over-current or fault protection in addition to the switching function. In some instances the capacitor switch may be required to switch the capacitor as much as twenty-five times per day, therefore the switch should be suitable for this duty and have the required momentary current and interrupting rating. Contactors may be adequate for small low-voltage capacitors where the fault current or momentary inrush current does not exceed the maximum rating of the contactor. Oil-immersed contactors may be used on small medium-voltage capacitors for distribution circuits on a similar basis.

The voltage-sensitive relay for voltage control as illustrated at the left of Fig. 1 should receive its signal from a potential transformer located at the point where the voltage is to be controlled—which may be on either side of the capacitor location. The current-control master element should receive its signal from a current transformer located on the load side of the capacitor to measure the uncorrected load current as illustrated in the center diagram of Fig. 1. The kvar control necessitates measuring the combination of both current and voltage and it is usually desired to measure the corrected load current. The current element of the master relay, therefore, should receive its signal from a current transformer located on the supply side of the capacitor as shown in the right-hand diagram of Fig. 1. The voltage element can receive its signal from a potential transformer located on either side of the capacitor.

"Range of adjustment" and "band width" must be given proper consideration on all regulating types of master elements. Range of adjustment is considered as the normal operating level of the device and it allows for the differences encountered in operating conditions. The band width is the difference between pick-up (contact closes to switch a capacitor on) and drop-out (contact closes to switch capacitor off). This band width must be larger than the signal change caused by switching the capacitor to prevent "pumping." For illustration, it might be pointed out that one of the conventional voltage regulating relays has a range of adjustment from 90 to 110% of its normal rating of 115 volts. The band width of this relay is adjustable from 3 to 7.5% of its normal rating.

Fig. 5 shows a simple voltage-sensitive relay which is used to initiate the opening or closing of the capacitor switch in response to a change in circuit voltage. This is an a-c. solenoid-operated moving-arm type of relay with moving contacts which travel between two stationary contacts with a permanent magnet for adjusting band width. The voltage range is adjustable by shifting the weight along the moving arm. The band width is adjustable by changing the position of the permanent magnet. The permanent magnet also provides quick "make" and quick "break" of the relay "contacts." This type of voltage-regulating relay is suitable for either single-step or multi-step automatic control for switching capacitors.

The current-sensitive relay is similar to the voltage relay except that it is equipped with an auxiliary transformer with taps to obtain wide range of ad-



2,62 Time Delay Relays

52 Circuit Breaker

$\frac{52}{a}$ Breaker auxiliary switch closes when breaker closes

$\frac{52}{b}$ Breaker auxiliary switch opens when breaker opens

$\frac{52}{aa}$ Cutoff switch closes in operated position of mechanism

$\frac{52}{cc}$ Breaker Closing Coil

$\frac{52}{T}$ Breaker Trip Coil

$\frac{52}{X}$ Type "30 F2" Control Relay

$\frac{52}{Y}$ Type "SG" Cutoff Relay

55 RKVA Relay -- R = Raise, L = Lower

62-A Auxiliary Tripping Relay, Type "SG"

101 Bkr. Contact Switch: C = Close, T = Trip, O = Off, M = Manual, A = Automatic. "A" is closed when handle is pulled out. "M" is closed in normal position of handle.

All devices are shown deenergized. Control Switch contacts "make" in position indicated. Phase Rotation 1-2-3.

Fig. 7. Schematic diagram of a typical single-step kvar control with Rectox solenoid-operated circuit breaker.

justment. This transformer saturates to limit the voltage on the relay coil. A current relay is suitable for single-step control only. If more than one switching step is desired, a separate current controller is required for each capacitor switch. In this case the current-sensitive relays should be adjusted for different current values to permit sequence switching operations.

A kvar-sensitive relay is shown in Fig. 6. This in an a-c. solenoid-operated moving-arm type of relay having both potential and current windings with moving contacts which travel between two stationary contacts. When the power factor is unity, the kilovars are zero and no torque is developed. If the phase angle between the current and voltage is shifted in the lagging direction (indicating an increase in lagging kilovars) a torque proportional to the lagging kilovars is applied to rotate the movable arm in the clockwise direction. Leading kilovars produce a torque in the opposite direction. The lagging and leading kilovar band width is adjustable as well as the range of adjustment. Permanent magnets are used to obtain quick "make" and quick "break" of the relay contacts. This relay is suitable for either single-step or multi-step automatic control for switching capacitors.

In the control circuits a certain amount of time delay is desirable to prevent unnecessary switching operations. This delay is obtained by a relay like that shown in Fig. 7 as devices 2 and 62. This two-element thermal-type time-delay relay times both the closing and opening of the capacitor switch.

A typical diagram illustrating single-step kvar control with Rectox solenoid-operated circuit breaker is illustrated in Fig. 7. Fig. 8 shows the control relays mounted on a control panel which is enclosed in the capacitor housing. If the control switch is in the automatic position and one set of the master elements contacts close, indicating that capacitor kvar is required, this will energize the closing element of the time delay relay. If the initial cause is not

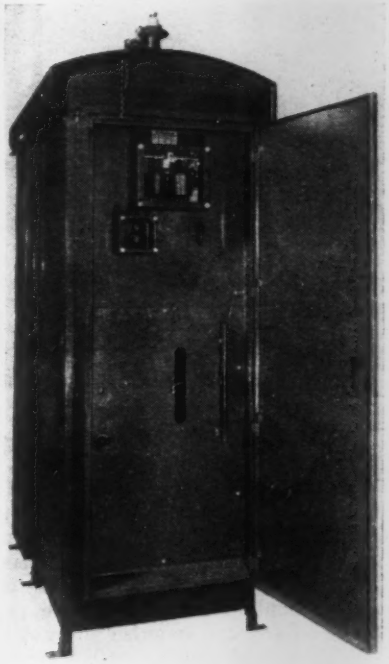
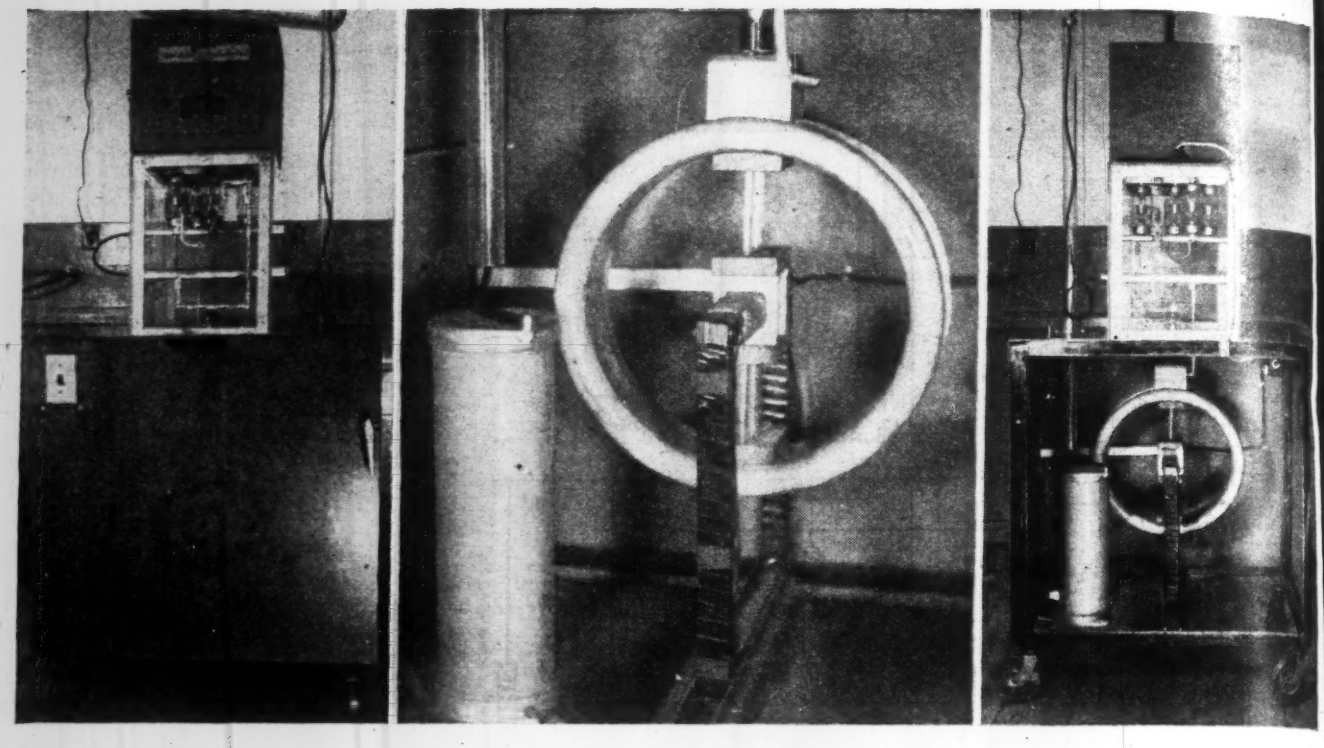


Fig. 8. Single-step kvar control panel enclosed in outdoor capacitor rack showing kvar relay, two-element time delay relay, and control switch.

a temporary disturbance, then the master element contacts will remain closed until the time delay relay contacts have closed, energizing the closing mechanism of the capacitor switch. The capacitor switch will then close and connect the capacitor to the circuit.

If, with the capacitor connected to the circuit, one set of the master element contacts close (indicating that the capacitor correction should be removed) this energizes the tripping element of the time relay. If the master element contacts remain closed for the time required for the time delay tripping contacts to close, then the capacitor switch tripping device will be energized, opening the capacitor switch and disconnecting the capacitor from the circuit.

The multi-step automatic controller operates in a manner similar to a single-step controller except that it is arranged to switch two or more groups of capacitors selectively and automatically by means of relays. *Continued on page 344*



A Peak Kilovoltmeter for Ignition Testing

By W. O. HENSCHKE, Ass't Research Engineer, American Bosch Corp., Springfield, Mass.

PERFORMANCE of electrical ignition devices, such as magnetos, is measured in several ways. The principal one involves measuring the peak voltage available under various load conditions and at various speeds. The ideal measuring device for this purpose would indicate the true peak voltage of any one impulse without applying any load to the ignition source and would be capable of doing this for impulses of either positive or negative polarity.

Spark gaps have been used a great deal for this application, but they are not sufficiently reliable for *measuring*. The voltage necessary to break down a spark gap is greatly affected by (1) the configuration of the gap, (2) the wave-form and polarity of the surge being measured and (3) atmospheric conditions, particularly with respect to ionization. Gaps have been variously stabilized by the use of ionizing electrodes and ionizing forces such as ultraviolet rays; and they have been maintained in a pointed condition in order to increase the spark length for a given voltage. In spite of these and other ingenious efforts to minimize errors, gaps are not reliable for voltage measurement.

Ignition equipment for aircraft application is, of course, made to Army-Navy specifications which set down various peak voltages that must be met. Suitable measuring equipment is therefore essential.

Spark ignition, as used on all aircraft engines, is at the present time being obtained from magnetos. The magneto produces a high-voltage surge, of relatively steep wave-front, that may appear of the same polarity each time a spark plug is energized or may alternate in polarity. Likewise, the polarity from one spark plug lead to another may alternate, and therefore it is desirable to have a measuring device that will perform equally well on either polarity.

Loading conditions during tests must be carefully controlled. The loads that are specified for test are used to duplicate the average distributed capacitance existing in the leads of the radio-shielded harness, and the shunt resistance that may exist across a spark plug that is still fit for use. These values are 250 $\mu\mu$f. in the first case, and 200,000 ohms to 400,000 ohms (non-inductive) in the second case.

The requirements for a satisfactory voltage measuring device may therefore be summarized as follows:

(1) Read peak voltages with the application of only a few impulses.

(2) Respond equally to either Input polarity.

(3) Extremely small input capacitance and very nearly the same input capacitance for either polarity.

(4) Low overall losses.

(5) Relative stability of losses under varying humidity conditions.

One method of meeting these requirements is to use an electrostatic voltmeter of the proper range, approximately 0-30 kilovolts, together with a suitable rectifier and filament transformer. The conventional type of filament transformer, as used for high-voltage rectifiers, is not suitable, particularly because there is excessive capacitance between the secondary winding and ground. Moreover, these transformers ordinarily do not have sufficiently high insulation resistance for this type of application. In order to overcome these objections, a special filament transformer was designed and an entire voltmeter equipment built on a portable stand, with this transformer as the basic unit.

Fig. 1 shows the design and construction of this filament transformer. It consists of a core made of 3.25% silicon electrical sheet steel, the individual laminations being 0.0188" thick. Straight laminations are used and built up with lapped corners into a square core 16" on a side. The primary is wound on a square paper tube and assembled to the core. The secondary form consists of a wooden ring with rounded edges. This ring has a 14" inside diameter and is 4½" wide with a wall thickness of 1" below the winding, thereby making the inside diameter of the secondary winding 16". The ring is made of maple by a pattern maker and is assembled without the use of metallic fastenings. The secondary assembly is supported around the primary by means of a wooden frame and four polystyrene rods. A free length of 3¾" of the polystyrene rods provides ample insulation.

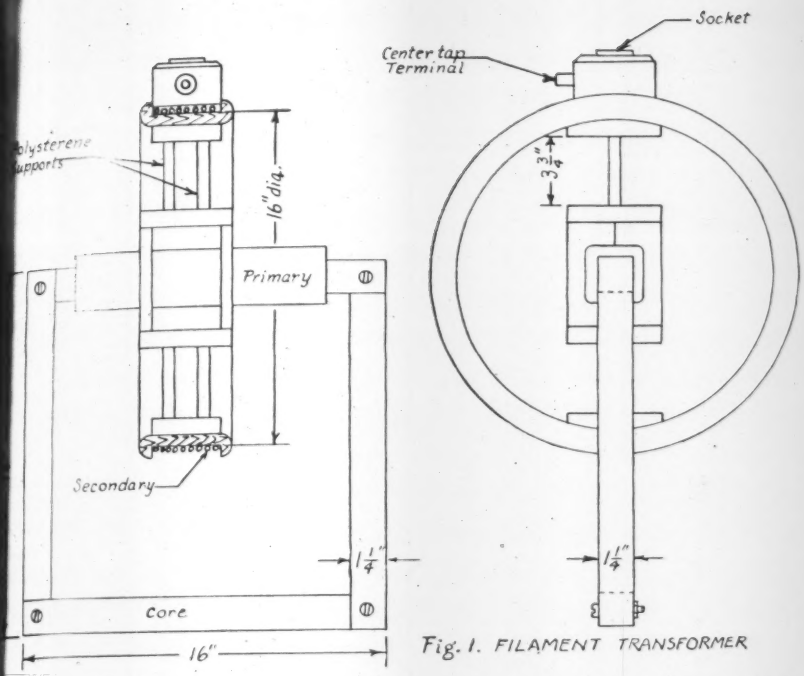


Fig. 1. FILAMENT TRANSFORMER

The rectifier tube is an 8013 rated:

Filament .....2.5 volts, 5.0 amps
Peak inverse .....40,000 volts,
Peak plate current.....0.150 ma.

To meet the filament requirements, the primary is wound with 660 turns of No. 20 single copper-covered enameled wire and the secondary with 21 turns of No. 9 double Formex wire. The regulation of a transformer of this type is poor and the design becomes possible only because of the fixed nature of the load represented by a filament. It is advisable, when building such a transformer, to check the output with a resistance load duplicating the filament requirement before making connections to the rectifier tube.

The complete circuit consists of a rectifier tube and a suitable filament transformer, means to apply both resistance and capacitance loads, a tank capacitor that may be charged to the peak voltage, and an electrostatic voltmeter to measure this voltage. Convenient means for changing connections to suit polarity are also included. All insulation must be of high grade and spacings generous. Losses are kept at a minimum by eliminating corona so far as possible and also using air or vacuum dielectrics wherever this may be done.

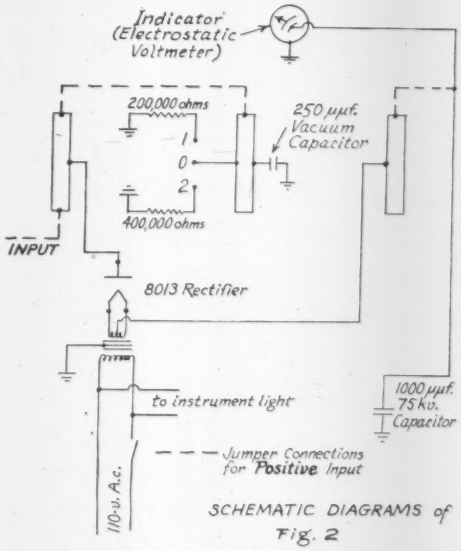
The measuring device described here incorporates a repulsion type of electrostatic voltmeter with a light beam as a pointer. This type of indicating instrument has some advantages but a less expensive type may be used with little sacrifice of accuracy. The physical arrangement of the parts is made to accommodate this indicator and could be varied for other instruments.

The transformer, rectifier tube and tank capacitor are mounted on an angle iron truck with casters. Side panels of Masonite are used on the truck to protect the apparatus and make a better appearing unit. The indicator is supported on a maple frame above the truck and polystyrene panels surround this frame. The panels provide high-grade insulating supports for the various connection terminals, and are of such size that ample clearance may be obtained between these terminals. The indicator is mounted on top of this structure with its scale at eye-level. The case of the indicator, the angle iron truck frame, the transformer core, and the ground points of the resistors and capacitors, are all solidly bonded and brought out to a terminal that is connected to ground when the instrument is in use.

Three bus bars extend between the two side panels of the indicator-supporting frame. These busses are so located that there is a minimum clearance of 5" between any bus and ground or any two busses. The bars are carefully smoothed and all edges rounded to generous radii to eliminate corona. Each bus terminates in a carefully rounded terminal on either side panel. This is done so that connections to the instrument may be made from either side, as may be convenient.

The middle bus bar supports the lower (live) end of a group of vacuum capacitors, the upper end of which is connected to ground just under the indicator. These capacitors are used to give a total input capacitance of 250 μμf. A lead also projects from this middle bus to the front polystyrene panel. Two resistors are mounted near the edges of this panel, one being 200,000 ohms and the other 400,000 ohms. Each resistor is made of 50,000-ohm non-inductive wire-wound precision units. A plug-in type of connector is used to connect either of these resistors to the central terminal, coming from the middle bus. The arrangement of resistors is chosen so that the greatest clearance may be obtained between live parts and ground. This clearance is a minimum of 3½" on the front panel.

The other two bus bars are used to make connections to the rectifier and indicator. The connections used for either positive or negative input polarity are shown schematically on Fig. 2 and Fig. 3 respectively. The photographs show front and rear views of the complete instrument, as well as a close-up of the transformer.



SCHEMATIC DIAGRAMS of PEAK KILOVOLTMETER
Fig. 2

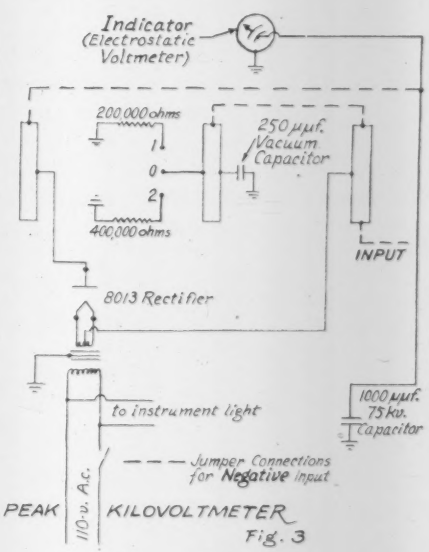


Fig. 3

Tests of the completed unit showed a total capacity of 10 μμf. between the secondary of the filament transformer and ground. The quality of the insulation also came up to expectations as shown by a test of the decay rate of the indicator reading. A test made by bringing the indicator up to a reading of 18 kv., disconnecting the high-voltage source, and taking observation at one-minute intervals showed an initial decay rate of 0.22 kv. per minute.

A discharge switch is provided to short-circuit the tank capacitor. This switch has a separation of 6" in the open position and is controlled from the front panel of the truck. The switch is a necessary item both to insure correct readings and for the sake of safety.

ELECTRIC
for Instruments a

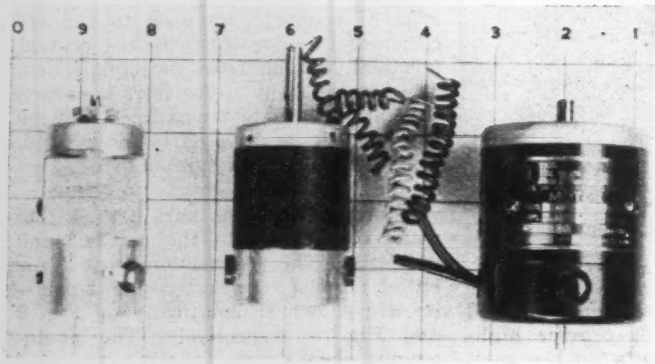
By HARRY D'ALM

(Cont

SUBFRACTIONAL, COMMUTATING AND D-C. MAGNET MOTORS

Developments in this field are almost entirely linked with the requirements for aircraft. Most of the motors in this category as now designed are for operation on low-voltage d.c. Those that do not have permanent-magnet fields, but instead use a laminated field core, could, of course, be wound for alternating current, and naturally windings can be modified to adapt them for higher voltages, although the insulating of such small motors for ordinary power line voltages of 115 volts or higher begins to present a serious problem. Clearances between parts and leakage paths are necessarily reduced.

Although these motors represent one of the newest developments in the motor field, they apparently do not have



Eicor, Inc. Three examples of midget motors against a ruled background indicating dimensions in inches. The top unit is rated approximately 1/80th horsepower at 1800 r.p.m. Continuous duty, 40°C. rise on 24 volts d.c. The middle unit is in a No. 1800 series frame, with a continuous maximum output of 5 watts, or an intermittent output of 22 watts. Maximum no-load as a series motor is 16,000 r.p.m., with a lot torque of 12 inch ounces. The lower unit is a Type PM motor with an intermittent output of 11 watts maximum at 4,000 r.p.m., efficiency 30 per cent.

any well-recognized application in the general industrial field for instruments or control apparatus.

If these individual motors do not have a large potential future, it is nevertheless true that the many varied demands of military aircraft for not only motors, but for motor control systems, will provide many improvements in this latter field of importance to industry.

Probably no individual motor demand in recent years has required production of similar units by so many different manufacturers and has actually put many new manufacturers into this end of the fractional horsepower motor business.

Some of the concerns prominent in this field are:

Delco Appliance Division, General Motors Corp.
Diehl Mfg. Co.
Fairchild Camera and Instrument Corp.
General Electric Co.
Globe Industries, Inc.
Lamb Electric Co.
John Oster Mfg. Co.
Small Motors, Inc.
Sperry Gyroscope Co.
Westinghouse Electric & Mfg. Co.
Air Associates, Inc.

Illustrative of this type of motor are the accompanying illustrations of Eicor, Inc. and Small Motors, Inc.

Many of these small aircraft motors are equipped with electric governors, and some of them with electric brakes. Some of them are shunt wound, some are series wound, and some are split-field reversible.

One of the notable contributions to small motor performance of commutating type motors has been the discoveries made in connection with brush wear as related to high altitude. As a result, notable improvements have been made in motor brushes which may materially increase the life of all brushes used in commutating machines. This development may be of significance in connection with possible industrial applications of commutating type motors where brush life was formerly one of the severely limiting factors to their extensive use.

FRACTIONAL HORSEPOWER COMMUTATING TYPE MOTORS

Motors in this category, ranging in frame sizes from about 2″ in diameter on up to 5″ or 6″ in diameter, in standard industrial general-purpose frames, are so well-known as to need no description. They have a very limited

Small Motors, Inc. Type SM-2 blower motor 1⅝″ O.D.

use in the field of instruments and control apparatus, except for certain blower applications and in some cases for operation of valves, dampers and hydraulic pumps and compressors.

Series motors having any one of a variety of special armature or field connections, known as compensated series motors, have been successfully used for motor-operated valves in sizes up to the small integral-horsepower range. The advantages of the compensated series motor are that it develops a speed torque curve that is approximately halfway between the conventional sloping speed torque curve of a series motor and the relatively flat speed torque curve of a shunt wound motor. Because of its ability to develop heavy torques at moderate speeds and show less speed change with varying load than an equivalent series motor, it has certain advantages where high output from a small mass of material is desired with intermittent service, such as in valve operation, or for certain positioning applications.

Just as in the case of the subfractional-horsepower motors discussed above, the most notable developments have been brought about by the demand of specialized aircraft mechanisms, which will find a limited and specialized use after the war.

Motors in this category have been extensively compounded with all kinds of gears, clutches, brakes, reversing windings, limit switches and positioning resistors, all built in as part of the motors. An illustration of one of these very special

MOTORS

Apparatus

rial Sale Research, New York

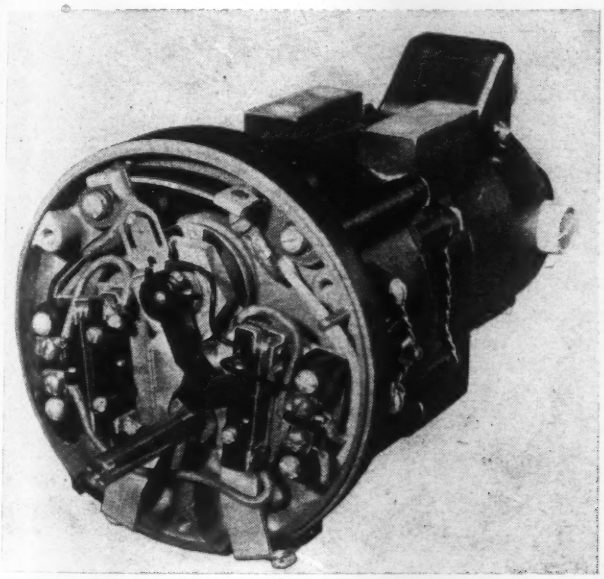
(Con pril)

types of units is the motor manufactured by the Dumore Electric Co. There may be some limited application of motors of this type in the field of instruments and control apparatus for indicating the position of dampers or valve mechanisms, although there are a large number of other position-indicating devices which in general may be better adapted. These will be discussed later.

1. Drag-cup Motors and Generators

A number of manufacturers, such as Kollsman Instrument Division of the Square D Co., Electric Indicator Corp., Sperry Gyroscope, and others, are producing what are known as drag-cup motors. These units were designed originally to drive the loop automatically for an aircraft radio compass. In this application the low-inertia characteristics of the drag-cup motor reduced hunting and the consequent pointer oscillation of the radio compass indicator, to a minimum.

These motors employ a two-phase two-pole stator winding. The rotating element consists of an extremely light cup of aluminum or copper attached to a shaft rotating



The Dumore Company split-field reversible series wound 24-volt d.c. aircraft motor with speed reducer, limit switches, and a built-in rheostat over which a moving contact operates, which is geared to the output shaft. Suitable connection of this rheostat to a distant instrument may serve to indicate the position of the driven apparatus.

on ball bearings. Whereas a two-phase motor employing a squirrel-cage rotor will operate the rotor at almost full speed with only one phase excited after the motor has once been brought up to speed by use of both phases, a drag-cup motor will not do this. On the contrary, interrupting the current to one phase while the motor is operating stops the rotor almost instantly. The excitation of the one phase acts like a dynamic brake on the motor.

Beside application as a motor, drag-cup units can also be used for several other applications when the shaft is turned by an external prime mover. In this case, it produces an output voltage which is a linear function of the speed over very wide limits.

To use it in this manner as an induction generator, one phase is excited with a.c., while the second phase serves as an output winding. The rotor in turning develops a quadrature voltage which is proportional to the speed of rotation. Thus it can be used as a tachometer, as a power tube output control through variable grid voltage, and in other related applications.

Speed-torque curves come very close to being straight lines, the torque increasing proportionately as the speed is reduced. The unit develops its maximum torque in the stalled condition.

A simple means of reversing the motor, and one which insures quick stopping, is to have a capacitor in series with each of the two windings with a single-pole double-throw switch so arranged as to alternately short out first one capacitor and then the other. When the switch is open, the current in both windings is in phase, which applies an effective brake to the motor.

These motors are currently made in two-pole construction for 60-cycle operation, or in six-pole construction for 400-cycle operation.

Comparison of the performance of two similar units, one with an aluminum rotor and the other with a copper rotor, is given in the following table:

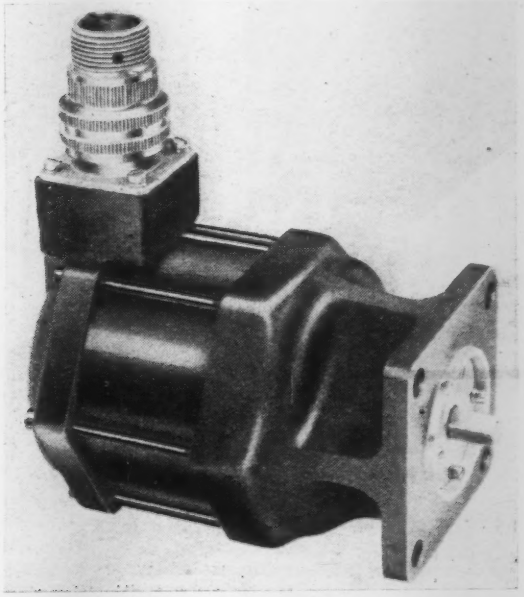
	Aluminum Rotor	Copper Rotor
Frequency—cycles per second	60	60
Condenser, phase 1—mfd.	1.4	1.4
Power input—watts	10.3	10.7
Number of poles	2	2
No-load speed—r.p.m.	3050	3060
Torque, stalled—in. oz.	0.577	0.700
Stopping time, no load, one phase energized—sec.	0.2	0.4
Reversing time—sec.	0.12	0.20
Moment of inertia in g.cm.^{2}	2.56	6.67
Temperature rise—°C.	56	60
Weight, complete motor—oz.	11.9	12

2. Special Generators

Another development, largely the result of aircraft requirements, involves the production of generating apparatus. Many of the small permanent-magnet motors are operated as d.c. generators. In addition, other small units have been designed as alternators to generate either single, two or three-phase current.

These units use a permanent-magnet rotating field and produce a very good wave-form.

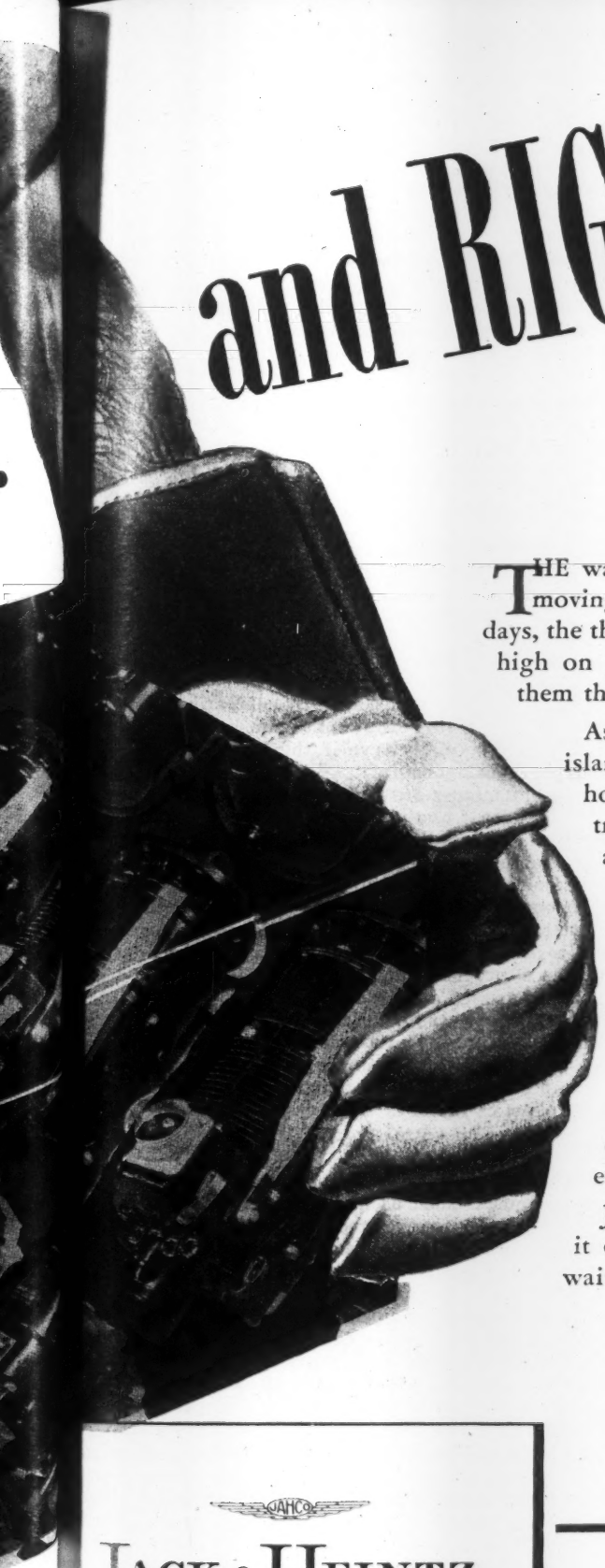
Somewhat in the same category has been the production of an inverted converter with an electric governor on the d.c. input side to maintain constant frequency output. Such



Kollsman Instrument Division of Square D Co. Two-phase AN specifications generator. Approximately one-half actual size.

Buy More War Bonds and Stamps

Enough...on Time...



and RIGHT!

THE war wouldn't wait—it has never waited—and today it's moving faster than ever. That's why, in the earliest, darkest days, the thousands of Americans at Jack & Heintz set their sights high on production of vital aircraft equipment—and will keep them there to the very end!

As the fighting turned slowly in our favor and now . . . island by island . . . mile by mile . . . draws closer to the enemy homelands, the tempo goes up and up and up. Doubled, trebled, quadrupled production assignments roll in . . . and the equipment rolls out at the same pace. Laboratory-precision products never before turned out in more than a few score are streaming to all fronts by the tens of thousands.

As a result of this intensive manufacturing experience, Jack & Heintz is today a group of several thousand time-conscious, production-minded people who have packed years of experience and know-how into months—broken all records in mass production of precision equipment—and kept faith with or beaten every deadline ever given them.

Just as this organization has kept pace with war, so it can help you in peace. For postwar competition won't wait, either—and the manufacturer who gets to market with *enough . . . on time . . . and right* will head the field.

JACK & HEINTZ
Incorporated

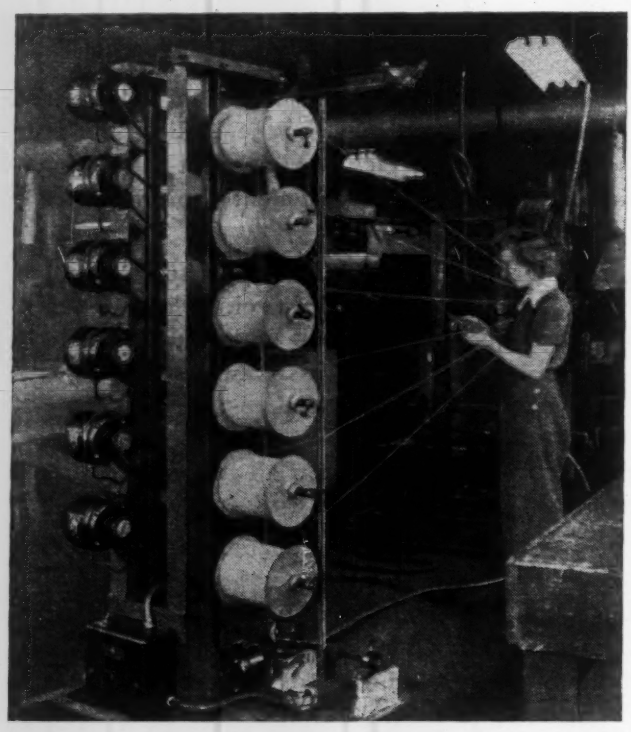
Jack & Heintz Inc., Cleveland, Ohio, manufacturers of aircraft engine starters, generators, gyro pilots, gyro flight instruments, magnetos, motors.

a unit has been used to supply 400-cycle current for operation of absolute altimeters.

An example of one of the special aircraft generators is the Kollsman two-phase generator, which is a high-impedance permanent-magnet two-pole generator which delivers 40 volts per phase at 20 cycles per second at 1200 r.p.m., with an approximately sinusoidal wave form. Three-phase low-impedance generators of similar construction are used in connection with aircraft electric tachometers. The unit illustrated is designed for mounting on a standard SAE and AN square-flange aircraft engine outlet.

3. High-Cycle Motors

Still in the category of a-c. motors using distributed wound stators of relatively small size, we must mention the extensive use—again in the aircraft field—of high-cycle motors. Most of these units are designed to operate at 400 cycles per second.



The Ohio Electric Mfg. Co. "Measured Torque" motors driving take-up spools for extruded plastics in the plant of the Carter Products Corp., Cleveland, Ohio.

The 400-cycle motor owes its existence to the fact that the output of a motor is almost directly related to speed. Thus it is possible to obtain an exceptionally high horsepower output from a very small motor. A typical 400-cycle four-pole motor with 1½" O.D. on the stator laminations and a 1" high stacking of these laminations will develop ¼ horsepower at 12,000 r.p.m., continuous duty. On a short-time rating a motor with a 2" stacking has developed 1 horsepower at 12,000 r.p.m.

A manufacturer prominent in this field states:

> To recapitulate, the 400-cycle motor field presents many possibilities, but in most instances where speeds under 4,000 r.p.m. are required we are faced with the problem of gearheads. Where small space is a factor and gearheads permissible, many things could be done in the way of power for control devices.

A fundamental drawback to the use of high-cycle motors in the industrial field has been the fact that the cost of providing the high-frequency source of power precludes their use for single-unit installations. They must of necessity be used where an entire system is involved, requiring many such units served from one source of power.

While high-cycle motor-operated portable tools are in use in factories where an entire production line is involved, they might not be in many instances well adapted to measuring-instrument or automatic-control apparatus use unless similar systems were involved. A somewhat parallel case exists in the control instrument field where air-operated instruments are used in completed systems. Such installations have to be extensive enough to justify the cost of the source of power, in this case an air compressor and rather expensive piping. However, there may be no equivalent to this which would require the large amount of power from a small mass of material that high-cycle motors can provide.

Thus, we are unable to comment on whether high-cycle motors have any place in the field of instruments and control apparatus or not. Perhaps not enough thinking has been devoted to this subject.

As a source of motive power there are available designs of small compact motor-alternator sets.

In any case, these small 400-cycle units represent an interesting development, and it seems advisable to include them in this survey as a matter of general reference.

4. Torque Motors

Torque motors are essentially alternating-current motors, having a sufficiently high rotor resistance to give a continuous speed-torque curve from the stalled position on up to maximum no-load speed. They are fundamentally designed to translate rotary motion into linear motion, and to approximate some of the characteristics of hydraulic cylinders in their ability to deliver a steady thrust. On a horsepower rating basis, they are quite bulky by comparison with a unit designed to deliver its output continuously at full operating speed. This is especially true if the torque motor must be designed for continuous duty.

Most torque motors are multiphase units. Of course, there have to be at least two phases in operation in order to produce the rotating field required to develop torque.

Torque motors can in some cases be used for process control work such as maintaining constant tension on a sheet of paper or on extruded plastics. In subsequent paragraphs we will have something to say about costlier motive power units applied to such applications by means which may, in particular cases, provide much more precise control of tension. However, where the requirements are not too critical, inexpensive torque motors having the right form of speed torque curve may be applied with considerable success. An example of such an application is the accompanying illustration of a group of torque motors driving take-up spindles in an extruded plastics factory.

5. Large Fractionals and Small Integral-horsepower Motors

In the operation of some of the larger pieces of process control equipment such as motor-operated valves, dampers, gates, blower units and related equipment, the field of small highly-specialized and precisely-built motors is left behind. Motors used in these related elements of the control apparatus field are more likely to be standard general-purpose type motors which may or may not be equipped with gearheads and built-in brakes or clutches, all of which are now available in the standard lines of a number of motor manufacturers. No illustrations are shown of these motors as they are so generally well-known, and the many manufacturers in this field have publicized such products extensively.

It might be mentioned in passing, however, that as many motors serving the process control industries have to frequently resist unusual atmospheres or operating temperatures, and as this requires many of them to be especially moisture-resistant, resistant to chemical fumes, explosion-proof, or be otherwise totally enclosed, the question of size versus operating temperature is frequently an important factor. The newest development that would affect the ability of motor manufacturers to obtain more power from a given mass of material is the production by the Dow Corning Corp. of an inorganic insulating varnish marketed under the trade-name of Silicone. The use of an inorganic impregnant with fibre glass insulation would permit the raising of motor temperatures and may be expected to have a profound effect on the design of all electric motors, large and small.

POSITIONING MECHANISMS, FOLLOW-UP MECHANISMS, SERVOMECHANISMS AND ELECTRONIC MOTOR CONTROL

1. Synchros

These units consist essentially of a bipolar laminated rotating field core excited by a single-phase alternating current through slip rings, which generate in a three-phase winding on the stator a series of single-phase unbalanced currents. If a second unit is connected in parallel with the first unit and the second unit is free to turn while the first unit is manually coerced, the second unit will maintain its rotor in the same relative position in space in respect to its stator as the transmitting unit is held in. Some of the applications of synchros are:

For indicating the position of:
Water wheel or steam turbine governors.
Bridges.
Railroad turntables.
Gates or valves.
Gas tanks.
Voltage regulator rotors.
Height of charge in furnaces.

For automatic control of:
System frequency.
Synchronizing generators.

For signal systems for the following purposes:
Steel mill furnace to blower room.
Grain elevator distribution systems.

For the remote control of:
Water wheel governors.
Variable speed motors.
Turbine governor load limit stops.

For recording changes in:
Gas or liquid pressures.

The versatility of synchros in the field of process control apparatus is almost unlimited. They possess two possible disadvantages, however, which in some cases make the use of other devices preferable. The first of these fundamental disadvantages is the fact that the restoring torque, when the follower unit is in the same position as the transmitter unit, is zero. In other words, there is no torque developed to restore the follower to the same position as the transmitter unit unless the follower unit is displaced from an equivalent position. The torque-displacement curve starting at 0° displacement and zero torque rises to maximum power at about 100° to 120° displacement, and then decreases to zero again at 180° displacement.

The second disadvantage inherent in direct-coupled synchros is that if the follower unit is for any reason held back from assuming the same position as the transmitter unit, it reflects this condition back to the transmitter unit, which then develops a torque tending to bring it into position with the follower unit. In order to overcome this, an amplifier is sometimes used between the transmitter and follower so that the follower cannot reflect its displacement torque back to the transmitter unit.

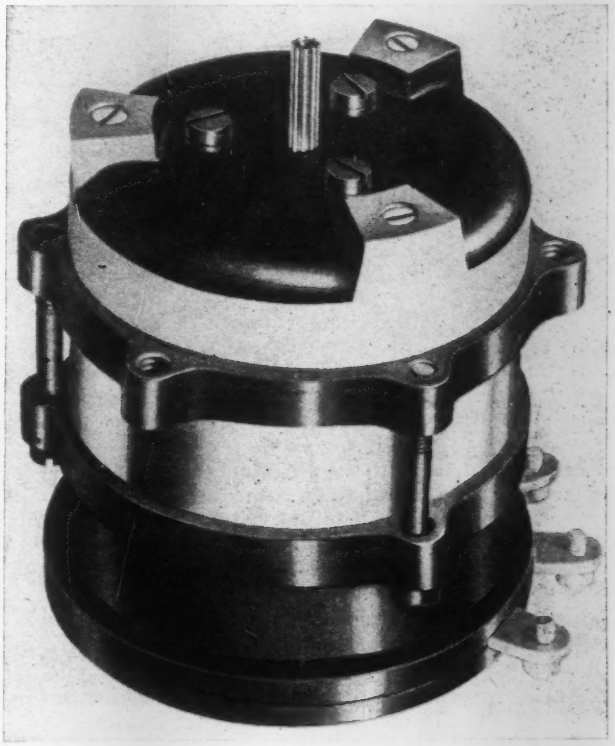
In addition to ordinary synchros as described, a number of manufacturers produce what is known as a differential synchro. In this case, the rotor is of different construction and is provided with a three-phase type of winding. A differential synchro thus has six wires, three from the primary and three from the secondary.

The purpose of the differential synchro is to modify the electrical angle transmitted by the synchro transmitter so that the synchro receiver will take up a position which will be either the sum or the difference of the angles applied to the synchro transmitter and the differential synchro. Conversely, if two synchro transmitters are connected to a differential synchro and each is turned through any angle, the differential synchro will indicate the difference between the two angles.

Through the use of the differential synchro there is obtained an electrical equivalent of a mechanical differential unit. Such units can be used for indicating the relative position in space, for instance, of two driving motors, each of these motors being coupled to a synchro transmitter, and the output from the differential synchro can be used to actuate controls that will speed up or slow down one of the motors so as to keep the two motors constantly in step with each other. If it was then desired to advance one motor ahead of the other so as to take up slack in, say, a sheet of material being driven by these motors, it could easily be done by rotating the rotor of the differential unit by any desired amount. A constant differential speed between the two drive motors could be maintained in order to exert a constant tension on material passing between them by advancing the differential rotor at a constant rate. Many other uses exist for the differential synchro.

Synchros can be made in any size required, and have been built for such purposes as driving a slurry feeder synchronized with a kiln drive, where the synchro is rated at 6 horsepower at 625 r.p.m. The General Electric Company have made application of their Selsyns to such installations.

The illustration of Kollsman's drag cup motor is almost identical with the appearance of their Teletorque unit, which is a synchro device.



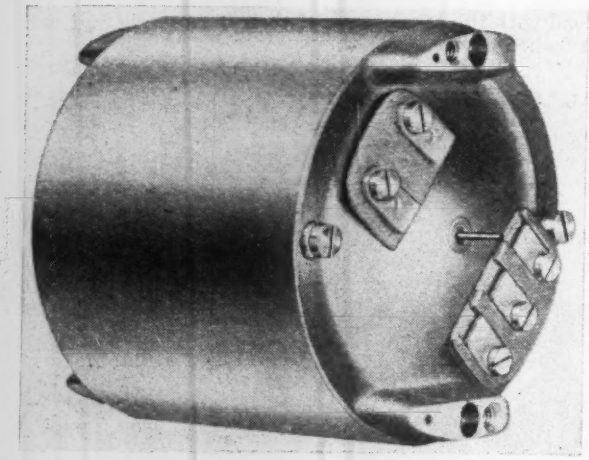
Kollsman Instrument Division of Square D Company. Drag cup motor Type 776-01. Actual size.

The synchro system dates back to about 1901, when General Electric introduced their Selsyns, but has not received very much publicity up to the present time. In recent years, marked strides have been made in automatic-control servomechanisms and fast-acting controls. This, along with large increases in a variety of devices, has called for an ever-increasing use of remote control and therefore synchro systems.

As a result of the development of servo systems, there has been developed a need for other rotatable motive power devices similar to the synchros and working in conjunction with them.

Next in importance to the use of the synchro itself is the rotatable transformer. The rotatable transformer is similar in construction to the synchro, with the exception that it has a cylindrical rotor instead of the bipolar salient pole type of rotor used in the synchro. In consequence, the rotatable transformer rotor offers uniform reluctance to flux regardless of the direction that the flux passes through it. The winding is accomplished by winding a two-pole coil into slots in the rotor. The connections are brought out through slip rings. As servomechanisms are growing in popularity, so rotatable transformers are growing in popularity.

The stator of the rotatable transformer used in a servomechanism is fed from a synchro transmitter or generator in the same manner that the synchro indicator or follower would be fed, but whereas the synchro follower would indicate mechanically any change in the position of the synchro generator, because the synchro follower has its rotor connected in parallel and excited from the same source as the synchro generator rotor, the rotatable transformer rotor will not rotate to follow the transmitter unit for the reason that it is not excited from an external source, but rather the voltage induced in it from the stator is used to indicate electrically any displacement in angular position between the synchro generator rotor and the rotatable transformer rotor. This generated voltage may be used to actuate a servomotor directly, or through amplifiers, which in turn will position



Kollsman Instrument Division of Square D Company. Telegon motor Type 315F. Outside diameter 1½", overall length 1½".

the mechanism driving the synchro generator until the induced voltage in the rotatable transformer secondary is zero; or, the presence of an output voltage from the rotor of the transformer can be used to operate a servomechanism that would position the rotor until the voltage was again reduced to zero and the servomotor was satisfied.

The rotatable transformer generally has a higher impedance than a synchro motor, and does not tend to coerce the synchro generator.

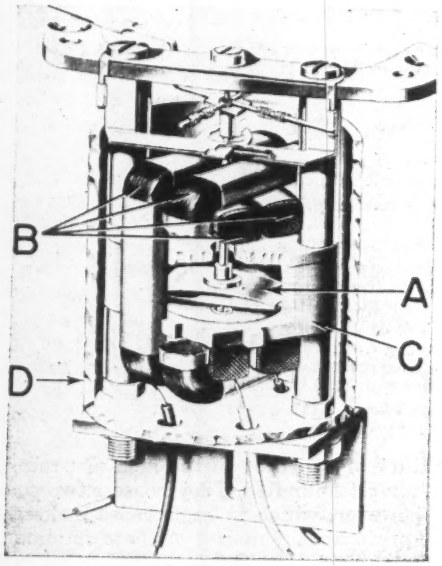
Rotatable transformers are used in conjunction with synchro generators and differential synchro generators.

There is a need in connection with servomechanisms for the use of synchro motors or generators that, instead of having the usual three-phase type of stator winding, have a two-phase type of winding. One such unit as this is the Kollsman Instrument Division's Telegon unit herewith illustrated. In this particular unit, all the coils are stationary, while the rotatable element consists of a shaft carrying a soft iron core and two silicon steel vanes. This core-and-vane assembly is energized from a primary winding which excites the rotor inductively. The secondary circuit employs two-phase windings disposed at right angles to each other in such a manner that with an a-c. source connected to the primary coil the voltage across the phase winding varies with the position of the rotor vanes. This has numerous applications. The variable-voltage output can be applied to a vacuum-tube amplifier, to operate a number of devices such as a follow-up motor for servo purposes, a higher torque Telegon position repeater, a cathode-ray indicator and other similar requirements.

In some servomechanism it is desirable to secure grid control of vacuum tubes by shifting the phase relationship between the grid voltage and the plate voltage. For this purpose, standard synchro generators with three-phase windings, or with two-phase windings, if properly supplied with actual three-phase or two-phase excitation, will generate a single-phase current in the rotor whose time-phase position in relation to that of any one of the impressed phases will vary with the angular position of the rotor. In other words, this small unit then becomes a phase shifter. Large phase shifters have been used for years in connection with various electrical measurements, such as laboratory tests on the phase angle of current transformers, or in checking the accuracy of the zero power factor creepage in watthour meters.

2. Magnesyns

Magnesyn is a registered trademark of the Bendix Aviation Corp. In the Magnesyn system, identical units are used for transmitter and receiver. In each case the stator is a toroidally wound tapped coil on a laminated magnetic core, and the rotor is a permanent magnet. Rotation of the trans-



The Edison "ratio meter" type instrument which uses a stationary coil (B) with a moving-magnet rotor (A).

mitter rotor causes corresponding rotation of the indicator rotor. Two taps are taken off from the toroidal winding at points 120° each way from the electrical ends of the winding. If these tap-off points are interconnected similarly between transmitter and receiver and the two toroidal windings operate in parallel from the same a-c. source, then manual coercion of a magnet operating as the rotor within the toroidally wound stator of the transmitter will cause currents to flow of such a nature as to develop a unidirectional field across a diameter of the receiver stator which will cause a permanent-magnet rotor to align itself with this unidirectional field, the angular position of this unidirectional field in respect to the stator being dependent on the angular position of the transmitter rotor.

The advantage of the Magnesyn over the synchros for certain applications is that the rotors have no electrical connections to them and, therefore, do not have to overcome any friction of brushes riding on slip rings. Another important feature of the Magnesyn system is the extremely low reaction torque on the prime mover. Magnesyns may be made with no source of friction except the bearings, and with jeweled pivots supporting a total rotor weight in the order of one gram, it makes these units very sensitive.

The fact that no brushes are used with a Magnesyn recommends it for use in explosive atmospheres, since there is no hazard of sparking contacts involved.

The simplification of construction of the Magnesyn recommends it for applications involving extremely severe service conditions such as vibration, wide range of ambient temperatures, dirt, and the effect of the elements.

3. Direct-current Positioning Devices

As in the case of the Bendix Magnesyn, the Edison ratio meter uses a stationary exciting coil with a moving-magnet rotor which is supported on jeweled bearings.

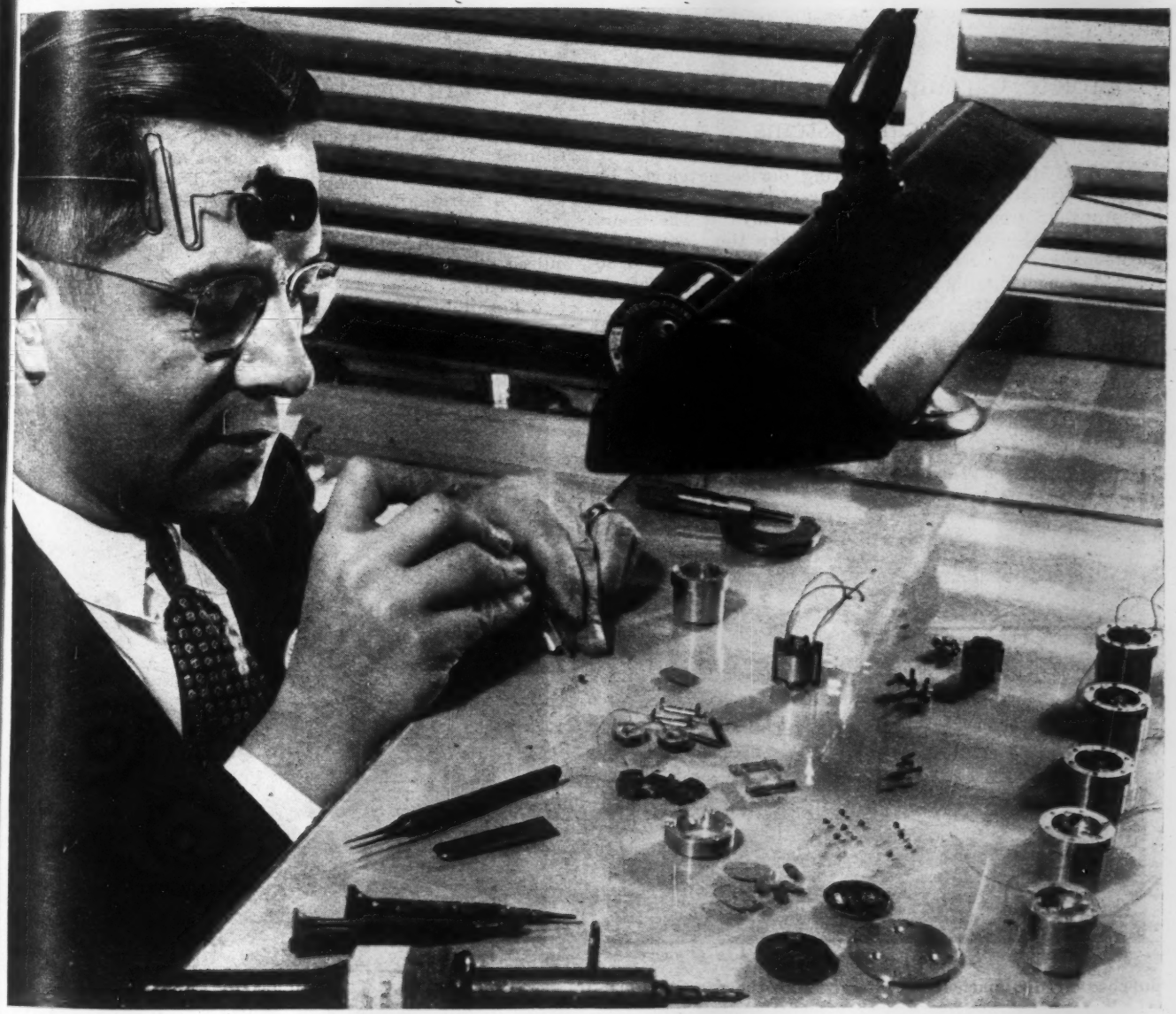
Continued on page 322

APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. I., No. 5 M. F. Béhar, Editor May 1945



THESE vibration-measurement pick-ups are not the smallest mass-produced aviation units: temperature-measuring elements in the form of fine wires (or perhaps bonded-wire vibration pick-ups) probably hold the record for smallness in this field of aviation instrumentation. But we mustn't quibble, for the news photo is a masterpiece—which we hope will not suffer too much in reproduction and printing on wartime paper.—MFB

Smallest and Biggest Mass-produced Aviation Units Made in Same Plant

BALTIMORE.—Smallest as well as biggest mass-produced units in aviation, it has been discovered, are manufactured by The Glenn L. Martin Co. at Middle River, Md. Maker of the JRM-Mars, biggest plane in mass production today, the Martin Company produces also a minute vibration detector weighing only two ounces which allows engineers to measure vibration and shock wherever they may be found. In spite

of their dramatic divergence in size, both products render important wartime services and both are directly adaptable for future civilian use. Relations between them are closer than might be expected of two extremes. Vibration pick-ups attached to wings and fuselage during test flights helped supply advance flight data that led plane designers to "beef up" the 120-foot Mars hull to its present structural strength. Several hundreds of these tiny accelerometers have just been completed for the armed services and for private aircraft companies, to be used during ground and flight tests in conjunction with electrical amplifying and recording units, also Martin-designed. Thousands of aircraftsmen work on the JRM-Mars, now in mass production for the Navy, but a one-man production line turns out accelerometers. An ex-watchmaker, trained to operate in fractions of millimeters, shapes each of the 72 minute parts.

Six More Reports on Employee-designed Testers, etc. at Glenn L. Martin Co.'s Plants

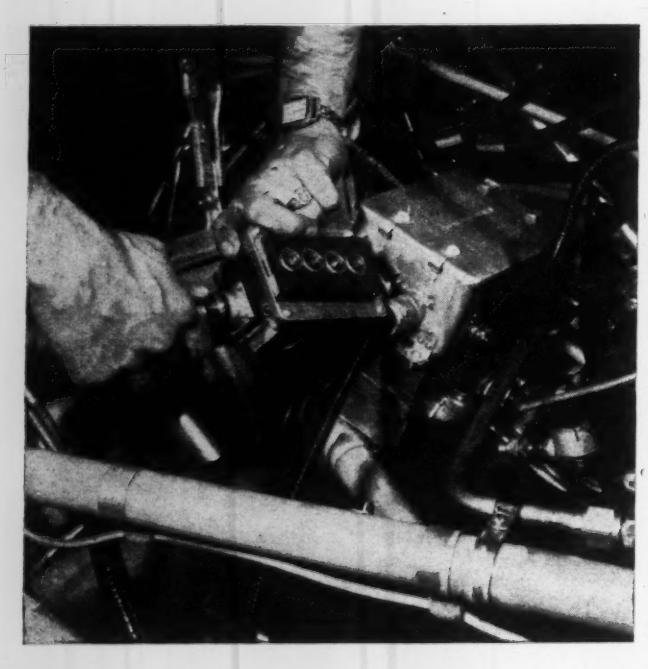
[Five were described in August 1944 *Instruments*, pages 464-467; single ones in other recent issues]

Complete Circuit Tester for Propeller Electrical Systems

BALTIMORE.—A trouble-shooting device developed by Marion Paskel and Adam Strausser of Airport Electrical has propeller gremlins on the run these days at The Glenn L. Martin Co. Simple and compact in design, the new trouble-shooter makes it possible to check the complete circuit of an electric propeller with the engine running, locating defects and bugs in a matter of seconds.

The Martin Electro-Trouble-shooter consists of a small fibre box mounting four lights hooked up in a multiple-purpose circuit, and can be plugged into the propeller electrical system either forward or aft of the prop relay box, or into the governor to provide three separate sets of checks.

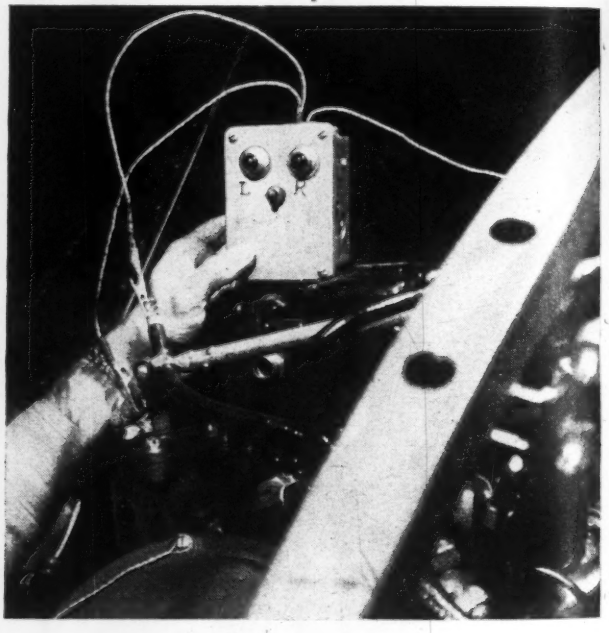
When plugged in ahead of the relay box, one light checks the automatic circuit a second increase manual and a third decrease manual. Plugged in aft of the relay box, one light indicates proper functioning of increase manual and a second that of decrease automatic. Hooked into the governor circuit, one light burns constantly while automatic, and two others flick on and off as the governor points open and close in increase and decrease respectively. Owing to the varied combination of circuits and attaching points, only four lights are needed to give a complete check of the propeller electrical system.



Improved Magneto Tester

BALTIMORE. — Checking magneto grounding at The Glenn L. Martin Co. has been greatly simplified through the development of a pocket-size testing device by Ralph Rutledge, a third shift Airport electrician. The new device not only provides a surer check than previous methods but in addition permits one man to do a job which formerly required two.

Rutledge's device consists of a small fibre box containing two flashlight batteries on which are mounted two lights marked R[ight] and L[eft] respectively. Three wires lead from the box, one of which is clipped to the ground tip of the right magneto, a second to the ground tip of the left magneto, and the third to an appropriate ground.



To check the magneto grounding, the operator merely attaches the three wires by means of a spring clip and sets the box up where it is visible from the cockpit. He then enters the cockpit and works the magneto switch on the instrument panel. If the magnetos are properly grounded the light marked R will go on when the switch is turned to "left," R will go out and L will come on when the switch is turned to "right," and both lights will go out when the switch is turned to "both."

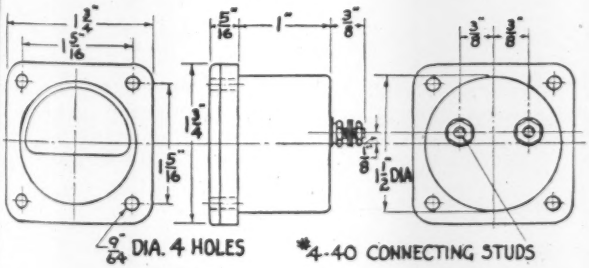
Before the development of the testing device two men were required for such a check—one working the switch in the cockpit, while another disconnected the wire and made

...

The New Line of ROLLER-SMITH 1½" Panel Instruments

Instrument shown actual size.

When desired, solder lugs can be furnished instead of the connecting studs shown.



Design and development of this line of 1½" instruments were based on rigid U. S. Army Air Force specifications. They are built to withstand extreme conditions of temperature, humidity, vibration and shock, and immersion tests have demonstrated their ability to withstand a hydrostatic pressure of 14.7 psi.

Roller-Smith 1½" instruments are now available in d-c voltmeters, 1000 ohms per volt, in all practical ranges above 100 millivolts, and 100 ohms per volt in ranges from 50 to 100 millivolts; d-c ammeters in all practical ranges above 500 microamperes. For certain applications instruments can be supplied with ranges below those specified. Correspondence is invited.

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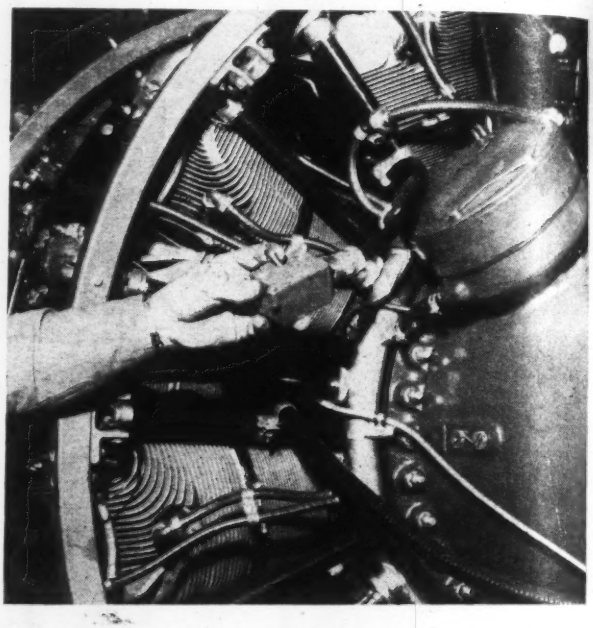
the proper connection. Not only did this require twice the manpower, but there always was the possibility of the two men getting their signals crossed as to which magneto they were checking.

Propeller-governor-relay Tester

BALTIMORE.—A new device to check the operation of governor relays on electric propellers—when the engines are standing still—has replaced the old practice of "wire jumping" with its attendant possibilities of error and damage. Developed by Adam Strausser, an employee in Aircraft Electrical at The Glenn L. Martin Co., the new device which is



used as a trouble-shooter to locate and check defects in the relay or relay wiring is contained in a small box about 1" × 2" × 2" and has a toggle switch mounted on the top face. In use the device is plugged into the relay circuit at the governor, and the relays are operated by flipping the toggle switch to one side for increase and the other for decrease.

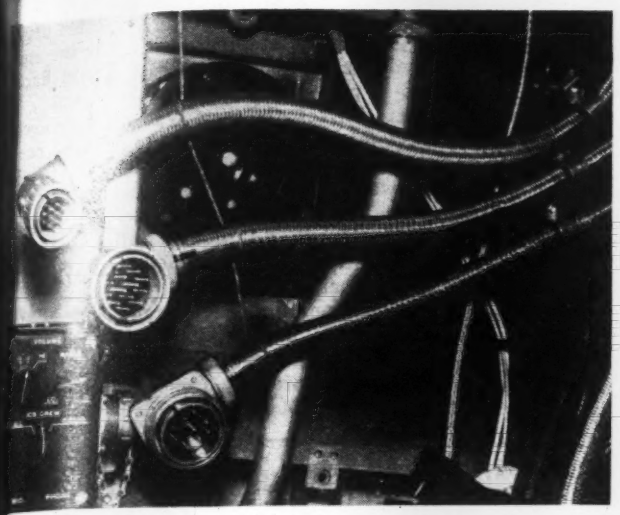
Like so many other employee-built devices, the governor relay operator not only simplifies the job of checking these items but, in addition, insures a far more accurate result than previous methods.

Marks Assure Proper Positioning of Multiconductor Cables

BALTIMORE.—A simple solution to the "time-honored" problem of installing and accurately positioning electronic equipment interconnecting cables has been devised by engineers of the Tool Division of The Glenn L. Martin Co. The new procedure is particularly valuable for facilitating critical cable assemblies and installations, since a large majority of electronic equipment troubles are traceable directly to cable failure.

Solution of the problem consists in merely painting two indicating marks on each cable, to locate the cable with respect to *the nearest structural clamp*, thereby accurately determining the location of the connector in the plane and also establishing the orientation of the right-angle connectors. This prevents twisting and possible breaking of wires when the cable is later connected to the equipment.

The indicating marks are applied to the cables by means of a special jig before installation of any wires. One of the most important features is that wire flow is established once and for all at the assembly point. With this method, the



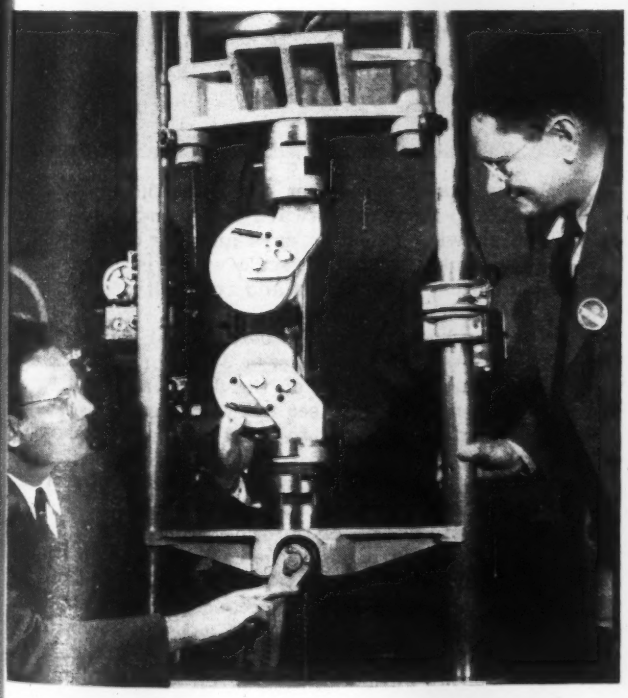
perator always knows definitely which way the wires are to ow, even before the plug is attached.

Before the adaption of the indicating system, the operator id not have this information and as a result many wires ere kinked or otherwise damaged within the cable.

mproved Clamp for Testing Strength of Control Cables

BALTIMORE.—Patent rights on a new quick-acting all-urpose cable clamp have just been issued to The Glenn L. Martin Co. in the name of its inventors, James J. Pasela and . Stanley Knockel, machine shop employees in the Martin ngineering laboratory. This device makes it possible at last o measure accurately the load of any cable, avoiding dam-ge at the crimped point and a consequent false breaking oint.

Suggested by the old seafaring trick of looping a rope round a capstan, the new invention (patent number 2,372,-62) features a dual pulley whose diameter is such that ten-ion on the cable is relieved and the clamp bears only a mall part of the strain. Additional feature is an automatic ocking bolt: an ingenious scissor mechanism consisting of



TELEVISION,
SINCE PIONEER DAYS,
HAS DEPENDED UPON
CANNON PLUGS

Because Cannon Plugs and Receptacles were designed especially for use in critical circuits, they were incorporated into the first television hook-ups. Says Harry R. Lubcke, Director of Television for the Don Lee Broadcasting System: *"We find Cannon Connectors indispensable in our television operations. We called on Cannon in 1937 and what was probably the first all-television connector was fabricated."*

All the circuits of a modern television camera pass through this single master Cannon Connector mounted on the side of the instrument. Equipment for the control of focusing, power and intensity of image is connected to power sources and to pick-up and broadcasting equipment through Cannon Plugs.

If you are interested in equipment of this kind, write for the Cannon Condensed Catalog. Address Dept. A-141, Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.

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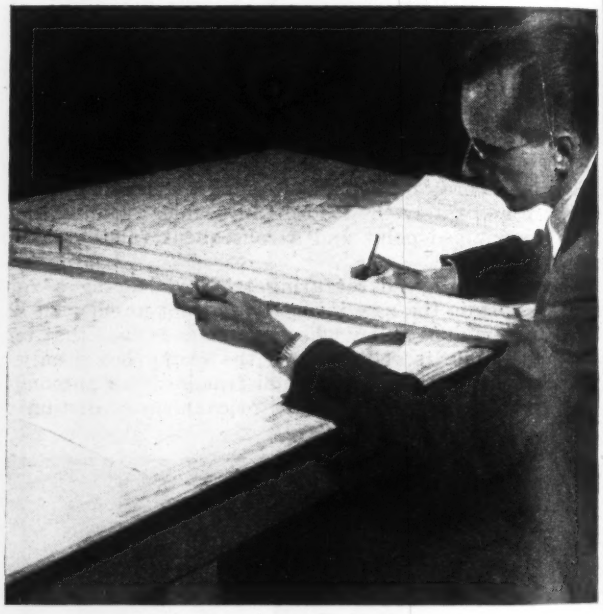
two cross slots so arranged that the pull of the cable urges the locking bolts into a firm clamping position at the ends of the cable. The self-locking bolt replaces fully 12 hand-adjusted bolts found in previous types of cable clamps.

A recent demonstration of the new-type clamp showed that only two or three minutes were needed to adjust a cable for test purposes, an operation formerly requiring up to half an hour. The clamp was attached to an Amsler testing machine, and steel cable of the same type used for control cables on the PBM-Mariner was inserted. Failure occurred precisely in the center of the cable, at a load point several hundred pounds above specification.

While the patent was pending, the clamp demonstrated was in constant use at the Martin laboratory and during that time required no repairs. Designed originally for 1/16" to 1/4" cables, it can be adapted to accommodate any size cable and to fit any type of machine.

Calendar-replacing Instrument

BALTIMORE.—Latest of the many casualties to fall before the onrushing tide of employee-designed and employee-suggested war production short cuts at The Glenn L. Martin Co. is none other than the calendar—which has recently given way, as far as the all-important matter of scheduling is concerned, to a new slide rule designed by George Wollinger of the Production Planning and Scheduling Department.



The Martin calendar replacer resembles the conventional engineering "slip stick" in outward form; and has two fixed scales—one showing calendar days and the other working days—and a double removable scale which is calibrated in straight numerical graduations and runs both forward and backward.

To determine how many days before final test it will be necessary to start the keelson of a JRM, or at what date detail parts would have to be on the floor with the new device, it is only necessary to set the working-days scale for the number of days required to build the part or assembly and the calendar-days scale for the date on which the part is due, and then read off the date on which it must be started —an operation which takes only a few seconds.

Before the introduction of the scheduling slide rule, long periods of counting off days on the calendar and computing results were required to produce the same informations. At best this took minutes as against seconds for the new device and, in some cases where there was a several months interval between the date to be ascertained and the known date, the computation period might even run into hours.

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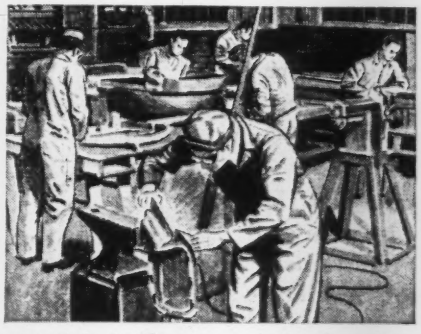
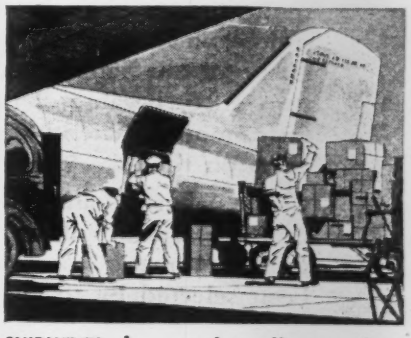


COST is insignificant compared with results achieved ($800 Air Express charges for thirty different shipments totaling two tons). Over 600 men are kept steadily at work — to say nothing of avoiding other losses when a war plant shuts down.



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SHOP KINKS

Screw Clamp

By LOUIS BERKOWITZ, Allston 34, Mass.

HAVE you ever tried to tighten a nut on a screw and had the nut and screw slip, and turn together in the same direction? This shop kink will tell you how to make a simple "screw clamp" which can grip a screw and prevent it from turning. The screw clamp can be made in five to ten minutes and it will not damage or mar the thread of the screw.

Some miniature instruments are so constructed that the head of the terminal stud is hard to get at. This may mean that in order to tighten a loose stud nut connection the instrument would have to be partly disassembled to hold the head of the terminal stud screw with a screw driver. This unnecessary work can be eliminated by making a screw clamp as follows:

FIG. 1

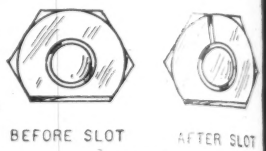

FIG. 2

Take a hex nut (brass preferred) of the same kind as the stud nut you wish to tighten and file down one side as shown in Fig. 1.

Cut a slot with a jeweler's saw as shown in Fig. 2 and it is finished.

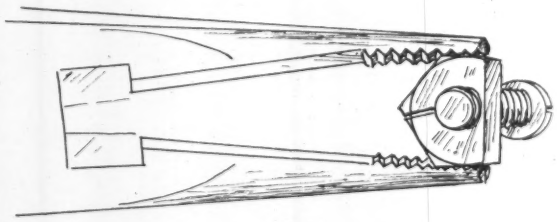
FIG. 3

The screw clamp is used by threading the clamp on to the loose stud and gripping clamp with blunt-nose pliers as shown in Fig. 3. Use an open-end wrench to tighten stud nut as snug as desired. Let go of grip on pliers and remove screw clamp.

This little gadget will save you many hours of precious time.

Tightening Binding Posts

By LOUIS BERKOWITZ, Allston 34, Mass.

WHEN binding posts are tightened in accordance with the method described below, there is no chance of a loose, intermittent, or varying connection between instruments and other apparatus. The method does not involve the use of tools; only the fingers are used.

DIRECTIONS

1. Open the binding post screw top;
2. Place the spade lug or connector between the top and the seat of the binding post;
3. Tighten the screw top snug with the fingers of the right hand;
4. Grasp at the same time: (a) the spade or lug connector with the thumb and first finger of the left hand and (b) the binding post screw top with the thumb and first finger of the right hand; and tighten both at the same time by turning them both clockwise for about one-tenth of a turn.
5. To open, reverse the above.

The writer using this method found that his fellow work-

Trouble for Tokyo

FILLING 2-TON BLOCK BUSTER, OFFICIAL OWI PHOTO.

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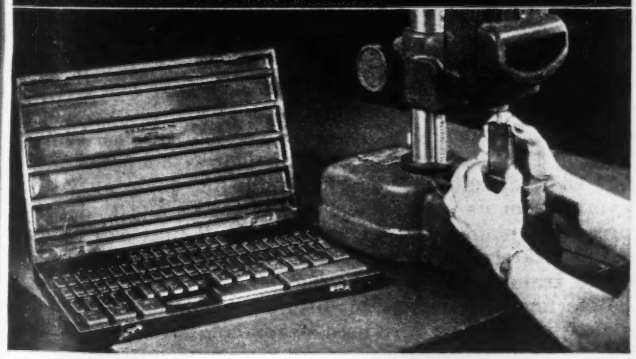

● Close-limit machine work calls for inspection standards regularly checked and re-established wherever necessary. Equipment for this kind of gage-testing used to be very costly. But not now. Johansson Gage Blocks are priced as low as $23 a set, with case—$3.50 for single blocks. They come in accuracies of .000004 and .000008. They will put your shop on a basis of enduring accuracy. May we send you a catalog with full details—sizes, accessories, prices? Write today.

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Double Header *Clean-Out* MANOMETER

This instrument is distinctive among clean-out U type manometers because of its *double* head—removable clean-out heads at both top and bottom. These heads are easily disconnected permitting quick and frequent cleaning of complete instrument.

The manometer (Model B-1275) has a large bore Pyrex tubing of 7/16" inside diameter which gives a flat indicating fluid meniscus. Bold numerals and graduations facilitate distant reading. Scale is adjustable.

B-1275 is designed for maximum line pressure of 100 lbs. per sq. in. It has holes for mounting to wall or panel. Ask for Catalog C-11 giving other features of this outstanding instrument.

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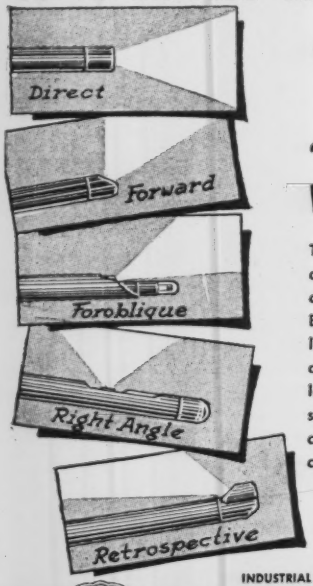

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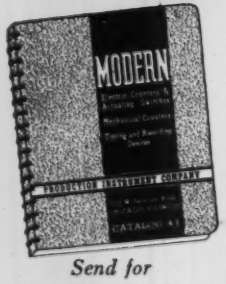

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ers could not open binding posts which had been tightened by the writer until the method was explained to them.

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SCHENECTADY, N. Y.—Superiority of a robot pilot over a human pilot in holding a plane on its course and in correcting for deviations from straight and level flight has been demonstrated by aviation engineers of General Electric.

Using a hook-up of an automatic pilot with a Link trainer, they showed that in a long, straight-line flight it will not deviate from its set course more than ½° and that it will correct the plane's attitude, when it is off-line, more quickly and accurately than a human pilot.

The trainer was used in the demonstration to simulate the stormy, unstabilized conditions a pilot might meet in a plane. Similar types are used in training fliers. They throw him into spins, dives and other dangerous attitudes, challenging him to bring the ship back to an even keel.

The G-E automatic pilot employed in the test is being used widely on Navy torpedo bombers. In the demonstration, G-E engineers showed that an automatic pilot will start its corrective action as soon as the plane begins to move off its course. Reactions of a human pilot are much slower, they found, because at least 0.1 sec. is required for the message that he is off-course to reach his brain, then he must have time to adjust his controls by hand.

"Secret of the speedy, accurate performance of the robot pilot is an electrical gyroscope which acts as the 'brains' of the system," according to engineers. "Any pitch, roll or yaw produces an electric signal in the gyroscope. This, in turn, is amplified and converted into mechanical power which

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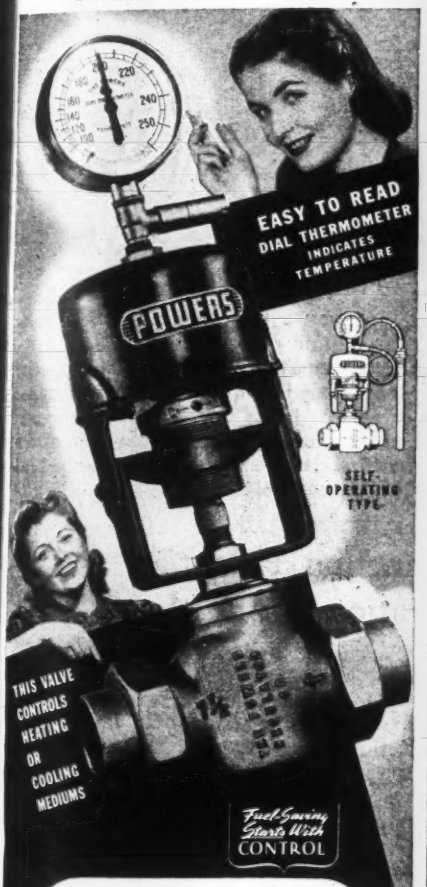

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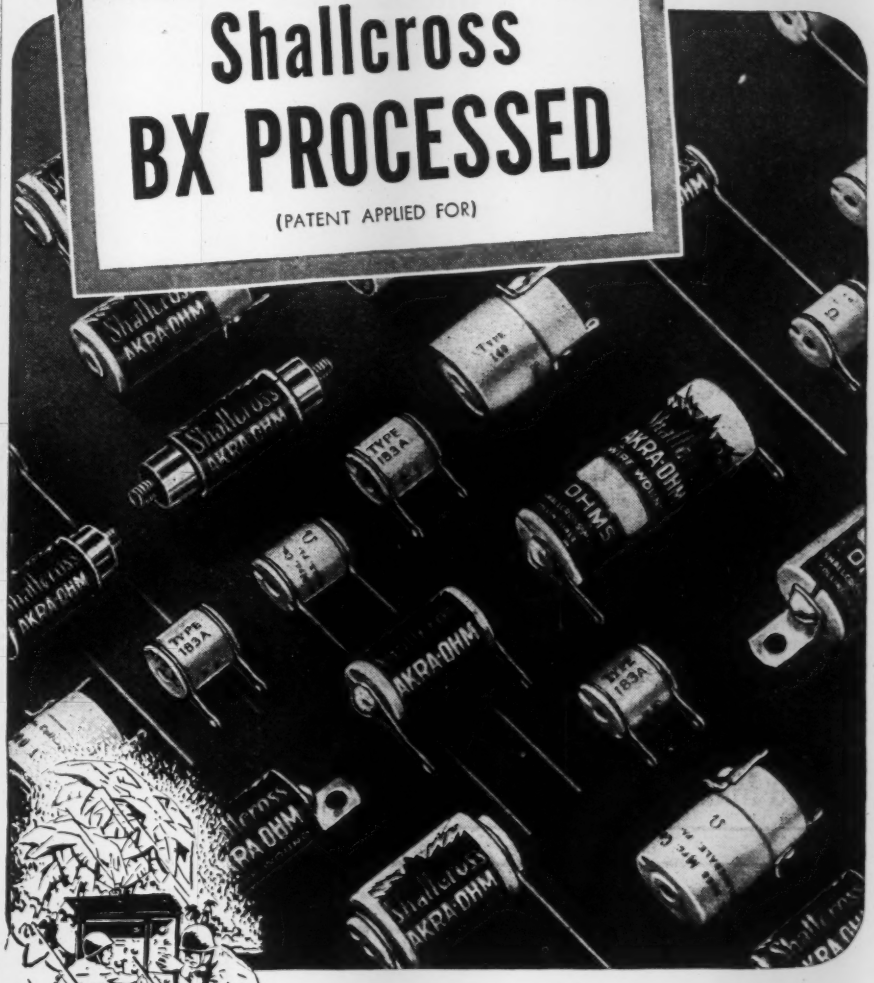

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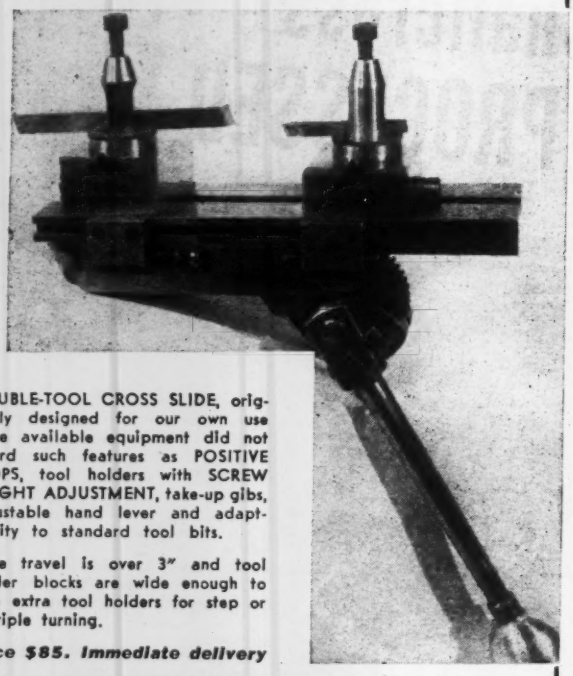

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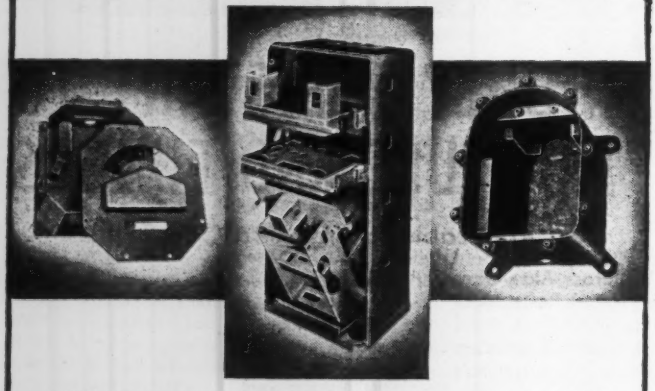

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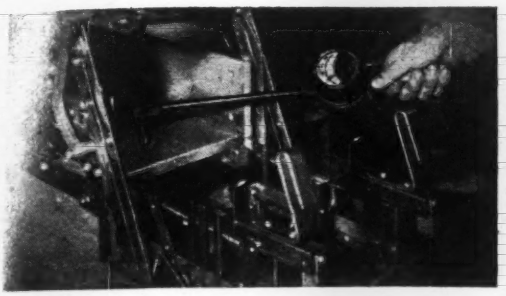
Liquid-junction Potentials and Calibration of pH Meters

THE advent of the rugged and stable pH meter of the vacuum tube type has made comparatively easy the measurement of the pH of most solutions with an accuracy within ±0.1 pH unit. The manufacture of a large number of medicinals and other products now requires a much greater accuracy in the control of pH, a step which has necessitated the investigation of sources of error formerly considered to be within the uncertainty of the measurements.

In the February 1945 issue of the *National Bureau of Standards Journal of Research* (RP1632), George G. Manov, Nicholas J. DeLollis, and S. F. Acree focus attention on one of the largest remaining sources of error (±0.05 pH unit) in pH measurements, namely, the potential generated at the junction of the standardizing buffer or unknown solution with the saturated potassium chloride solution which forms the electrolyte of the reference electrode. Among the lesser sources of error in pH measurements are the asymmetry potential of the glass electrode, thermal and electrical hysteresis of the calomel electrode, temperature inequalities in the cell system, and unknown salt effects.

In measuring the pH of unknown solutions or in calibrating the scale of a pH meter by the use of two or more buffers, it is the difference between the liquid-junction potentials of the calibrating buffer and of the unknown solution, respectively, in contact with the saturated potassium chloride which must be considered. A method is described by which these differences in liquid junction of two solutions of known pH can be obtained with a precision of ±0.002 pH unit, and which is independent of the nature of the reference electrode. The experimental data on hydrochloric acid, phthalate, phosphate, phenolsulfonate, borax, and calcium hydroxide buffers containing sodium or potassium chloride and ranging in pH value from 1.081 to 12.38 were also used to check the consistency of the calibration



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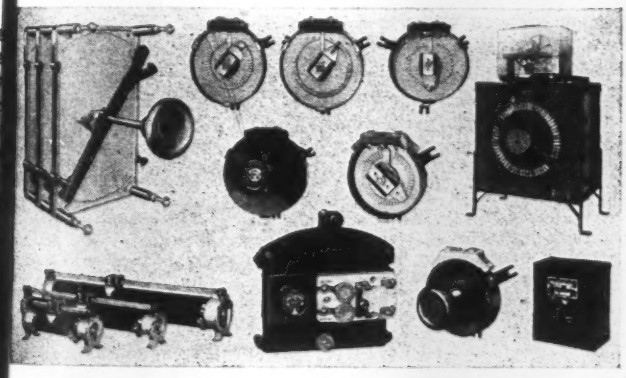

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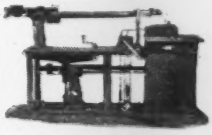

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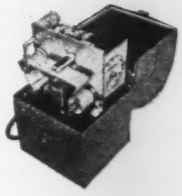

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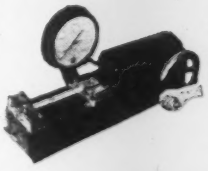

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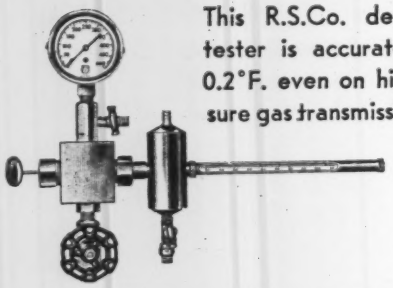

This R.S.Co. dew point tester is accurate within 0.2°F. even on high pressure gas transmission lines.

With this dew point tester it is possible to determine the dew point of gases under the conditions of pressure as they are found to exist; and, dew points can be accurately determined with safety at high pressures.

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of the scales of pH meters with the various buffer standards recommended by the Bureau for this purpose. The results show that the maximum error caused by the accidental displacement of these buffer standards from their theoretical position in the pH scale by carbon dioxide and other impurities is less than the sensitivity of the average pH meter (0.01 unit). Data are also given for the calibrations of Type 015 and "low alkali error" glass electrodes of commercial manufacture when tested against seven buffer solutions.

ELECTRIC GAGING METHODS

Continued from Page 303

Even greater improvement in response may be secured if some impedance-changing device is installed in the detector circuit so that the circuit output may be carried to the control units over low-impedance leads. Low-impedance lines are much less subject to inductive interference than high impedance lines.

No analysis has been given for the application of these circuits in deflection methods. Such use is entirely satisfactory only when the design and construction of the device provides for initial balance both in magnitude and in phase and thereafter permits no unbalance except through change in capacitance of the primary element. When this condition obtains, any unbalance of the circuit indicates a change in the magnitude being measured. The output of the circuit then is approximately equal, in volts, to the applied potential multiplied by one-fourth of the percentage change in one impedance arm—or one-half the percentage change in each impedance arm if a ratio-type primary element is used.* This relation holds for small changes only.

In a properly designed circuit, the presence of resistance in the measuring arms of the circuit need not introduce inaccuracy. Good practice of course requires experimental verification of sensitivity and calibration, and frequent rechecks. But since any circuit output resulting from a resistance unbalance will be 90° out of phase with the output from the reactance unbalance, if the detecting device is phase-discriminatory it will respond only to reactance unbalance, and will not give any indication in response to resistance changes. In the discussion of detecting devices this effect will be discussed in some detail.

To be continued

*A brief discussion of this action was given in the description of resistance bridge circuit in a previous chapter; a detailed discussion will appear in the discussion of resistance bridge circuits in the next instalment.

ELECTRIC MOTORS

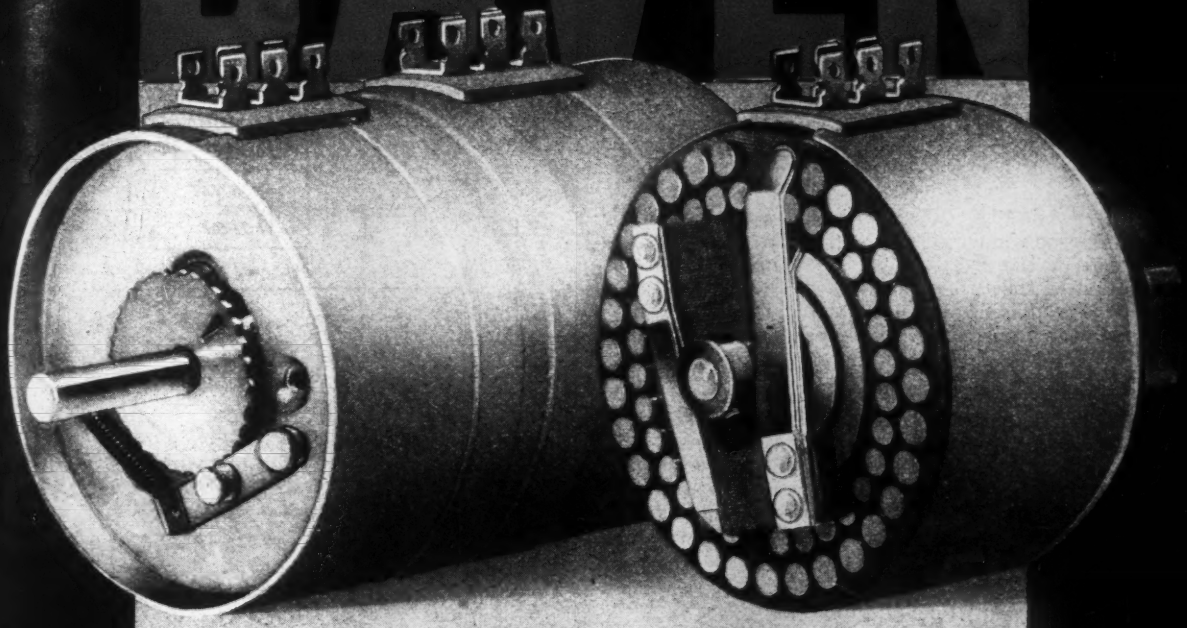
Continued from Page 316

Many indicator problems are well solved using the characteristics of a ratio instrument, wherein the indicator response is proportional to the ratio of the driving magnitudes and is independent of their absolute value. The use of such a position-indicating system makes possible resistance thermometers, remote position indicators, and ohmmeters which are independent of supply voltage variation. A variety of types are possible. One using four coils may provide for 360° continuous rotation.

There is no basic patent on the principle employed in these movements.

A variation of this principle has been in use for some time by several companies. Bendix refer to it as the d-c. Autosyn. The transmitter is a continuous circular resistance with three equally-placed taps contacted on a diameter by a d-c. voltage. When connected to an indicator similarly wound with a continuous winding on a magnetic iron core, a d-c. field will be set up across a diameter of the indicator corresponding to the diameter of the transmitter that is contacted by the d-c. voltage. The rotor of the indicator can then be a

DAVEN



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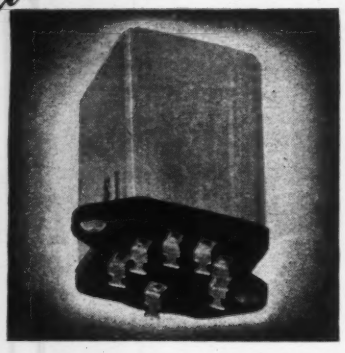

The 5 RPL relay has two coils with separate terminals which may be connected to independent pilot circuits. The load of the relay is operated only by the co-ordination of the two pilot circuits. This may be the sum or the difference of the pilot circuit voltages depending on the polarity of coil connections.

The same result can be accomplished with the unmounted type 5 F relay but the enclosed form is usually preferred. Both types are widely used in aircraft applications where circuit co-ordination is desired.

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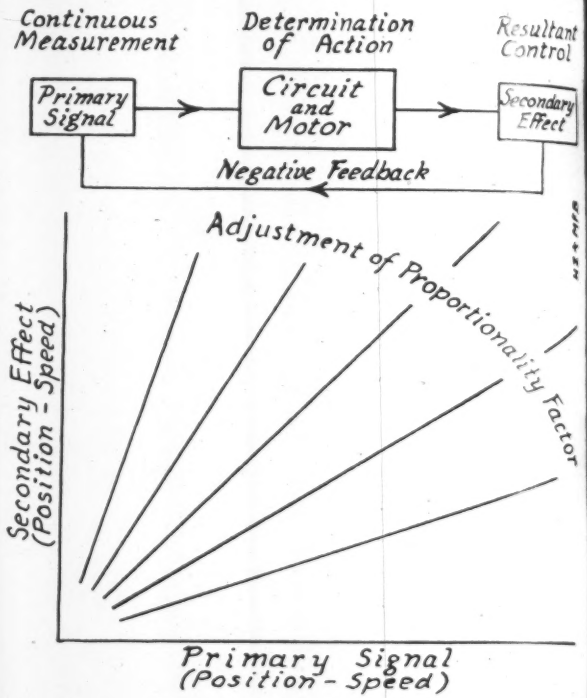
permanent magnet, which will align itself with the indicator field.

4. Servo Systems

It is difficult to separate a discussion of positioning mechanisms such as synchros and Magnesyns from servo systems, because to talk about one of them is to automatically discuss elements of the other.

A simple system of transmitter and indicator such as a synchro does not constitute a servo system, yet servo systems rely heavily on the ability to transmit an indication of position from one point to another, which position transmission may involve the reporting of elements rotating continuously at high speeds.

The diagram shown herewith (through the courtesy of the Askania Regulator Co.) is a simple servo system. Other



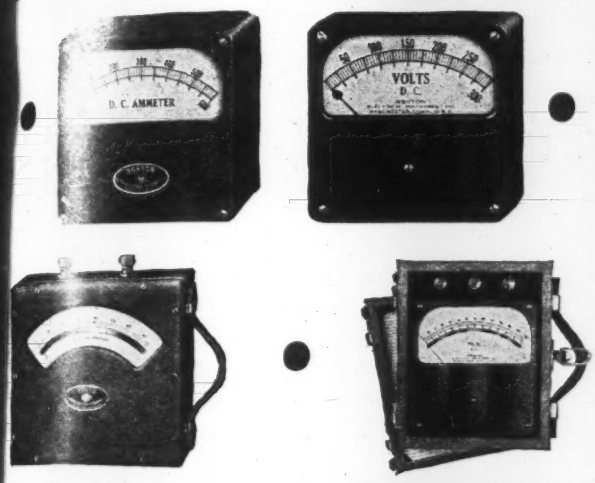
mechanisms which are an integral part of many servo systems widely used in the industrial field are the Ward Leonard system of generator voltage control and the General Electric Amplidyne.

The Ward Leonard system consists of a motor-generator set having a variable field excitation which is controlled from the input signal, while the generator supplies a motor driving the load which has fixed field excitation. The Ward Leonard system is not a specific unit manufactured by the Ward Leonard Company. It was originally produced by them many years ago and is now generally referred to by that name, though practically any manufacturer can furnish a Ward Leonard system of motor control. The Ward Leonard system, unlike the Amplidyne, does not depend on any regenerative circuits in the generator, and therefore the generator output bears a lower ratio to field excitation input than in the case of the Amplidyne. In order to secure smaller values of control current to be handled, as well as more nearly approximate the relatively constant current excitation characteristics required for the field control on an Amplidyne, the field excitation to the generator in the Ward Leonard system is often in turn supplied from another smaller motor generator. By using two Ward Leonard units cascaded in this fashion, large outputs can be handled with a small input control current. In such an application there is an appreciable electrical inertia which affects the quick response of the system to changes occurring at the control point.

The General Electric Amplidyne, illustrated herewith, is a high-speed generator in the sense that its speed is a part of its quick adjustment to varying demands rather than any reference to rotational speed. It is claimed that the Ampli-

NORTON

Electrical Instruments



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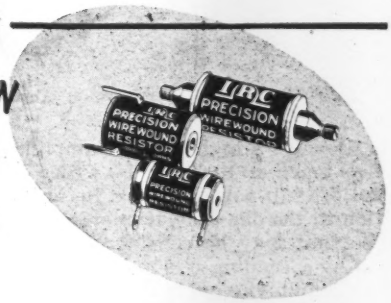

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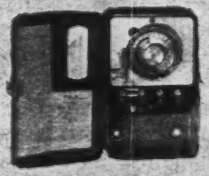
*A unit for every time control need



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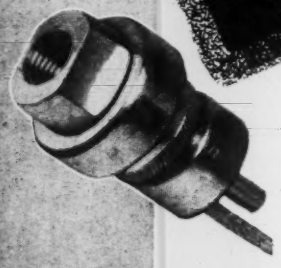
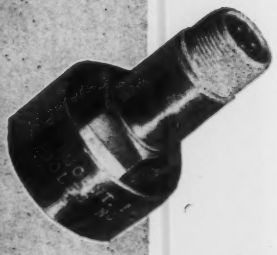
Trimount Series "A" and "N" Dynamic Pressure Gauges have wide application in aircraft and automotive fields, and in many other industries. They outdate, and are superior to, conventional instruments. Other dynamic gauges available for taking indicator cards on steam, gasoline, Diesel and gas engines, and on pumps and compressors.



The Trimount Series "A" Dynamic Pressure Gauge. The newest instrument for aircraft boundary layer and air foil pressure distribution studies in the laboratory or in test flight. Sequence readings can be made with banks of these instruments by means of a special Trimount switching arrangement, and studies impossible with conventional instruments are readily achieved. Features include: Frequency Response 0-500 C.P.S.; Sensitivity .4 of 1%; Linear Undistorted Pressure Response; Exclusive Integral Phase Balancer.



The Series "N" All-Purpose Differential Type Dynamic Pressure Gauge. For ground and flight test aircraft studies and in many fluid systems, such as fuel systems, intake manifold systems, and in many other locations. Gauge operation is simple. Extreme accuracy. Write today!

Electronics Division

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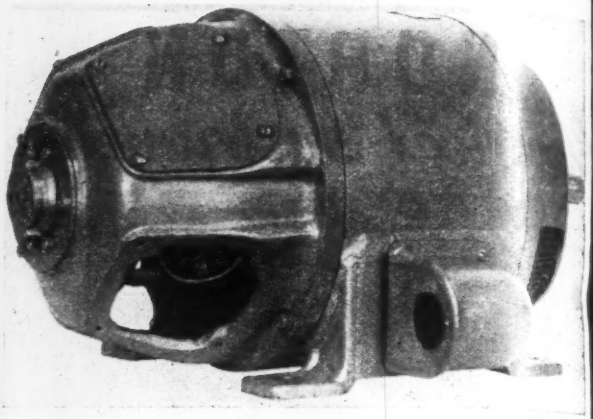
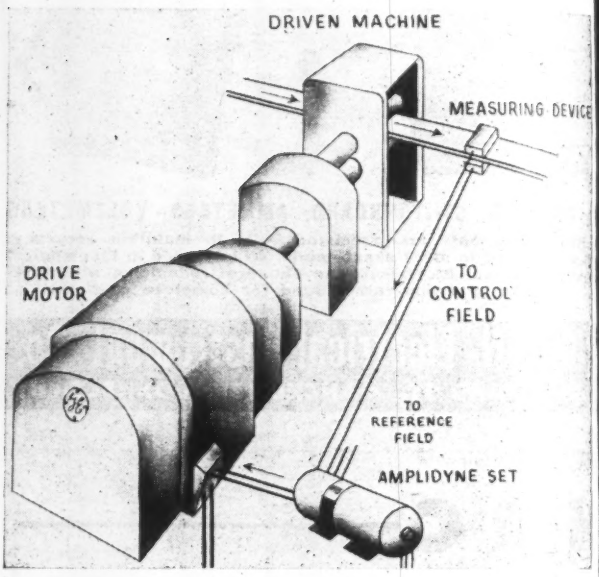


General Electric Co. Typical 3-kw. Amplidyne



Typical Amplidyne application (General Electric Co.)

dyne provides a high ratio of amplification of the input signal—as much as 10,000 to 1—with a speed of response of 0.2 second for full-power output. Because of the range of amplification in the one unit, it is possible to obtain a speed of response that may be considerably better than would be obtained by cascading two motor-generators.

The Amplidyne generator employs a set of brushes in the normal position, but in place of supplying the load they are short-circuited. The field excitation and the field coil are made very small so that the short-circuit current flowing is much less than it would be if a full conventional field were used. The short-circuiting of the brushes increases the armature flux to the original value it would have in a conventional generator. Two additional brushes at right angles to the short-circuited ones and operating in the field of the armature flux supply the load through a compensating field winding which is added to neutralize any tendency of the load current to set up its own armature flux in opposition to the control flux. Thus, control of a very small amount of original field excitation produces very large changes in the output of the generator.

The application of an Amplidyne to a simple closed-cycle control scheme would be as shown in the accompanying illustration.

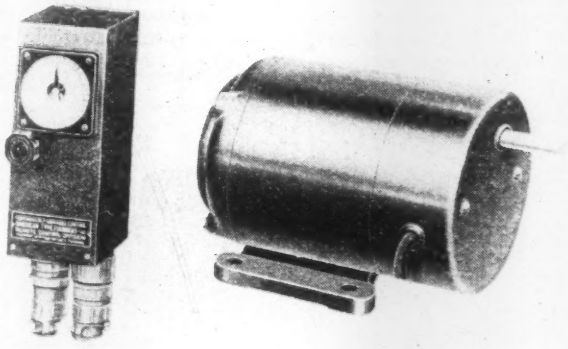
5. Yardeny System

American Type Founders, Inc., Remote Control Division, are manufacturing an interesting form of positioning and follow-up mechanism which is distinct from synchros and Magnesyns in that the transmitter and the follower do not constitute a self-synchronous system in which the two units

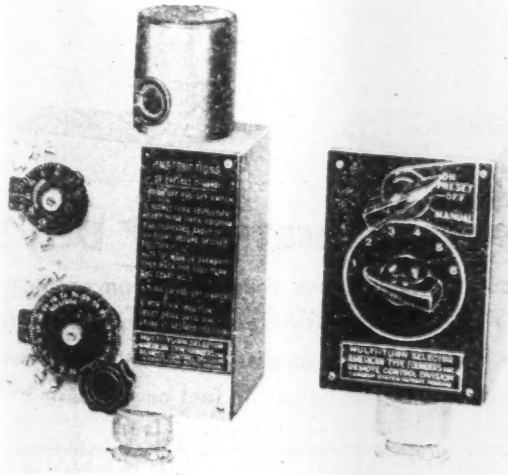
always operate in time and space phase relationship to one another. Nevertheless, it is possible to control a servomotor at a distant point by a control unit in such a manner that a preselected position set by the control unit will cause the follower unit to finally come to rest in a definite position. Even if the unit, owing to the inertia of the motor armature, overshoots, it automatically reverses and comes back to the predetermined point. This is accomplished by a combination of ingenious contacting devices built within the control unit and incorporated as part of the servomotor unit.

In the accompanying illustrations, if the knob on the continuously variable control unit is turned to the right, the shaft of the servomotor turns to the right, and vice versa. The control knob may be turned a small amount, which will cause the servomotor to rotate a small amount for each impulse transmitted to it through the control knob. If the control knob is spun, the motor at the control point continues to drive the control and the servomotor continues to run in the direction selected. If the control knob is grasped and held so as to stop the operation of the motor in the control unit, the servomotor stops. By an interconnection between motor and control unit, a dial on the control unit serves to indicate the position of the servomotor. Thus the servomotor may be "inched," or may be made to advance in either direction, through a continuous series of revolutions. This is known as the continuously-variable control unit.

In the second illustration, that of the Multiturn Selector, a series of fixed positions may be selected at will by turning the pointer knob in the right-hand unit. The exact positioning of the servomotor is secured by settings which are predetermined through manipulation of the dials appearing on the unit illustrated at the left. The upper of these dials de-



American Type Founders, Inc., Remote Control Division. Yardeny system, illustrating continuously variable control station with control knob and servomotor position indicator dial, and reversible servomotor with gear reduction and built-in position-indicating means.

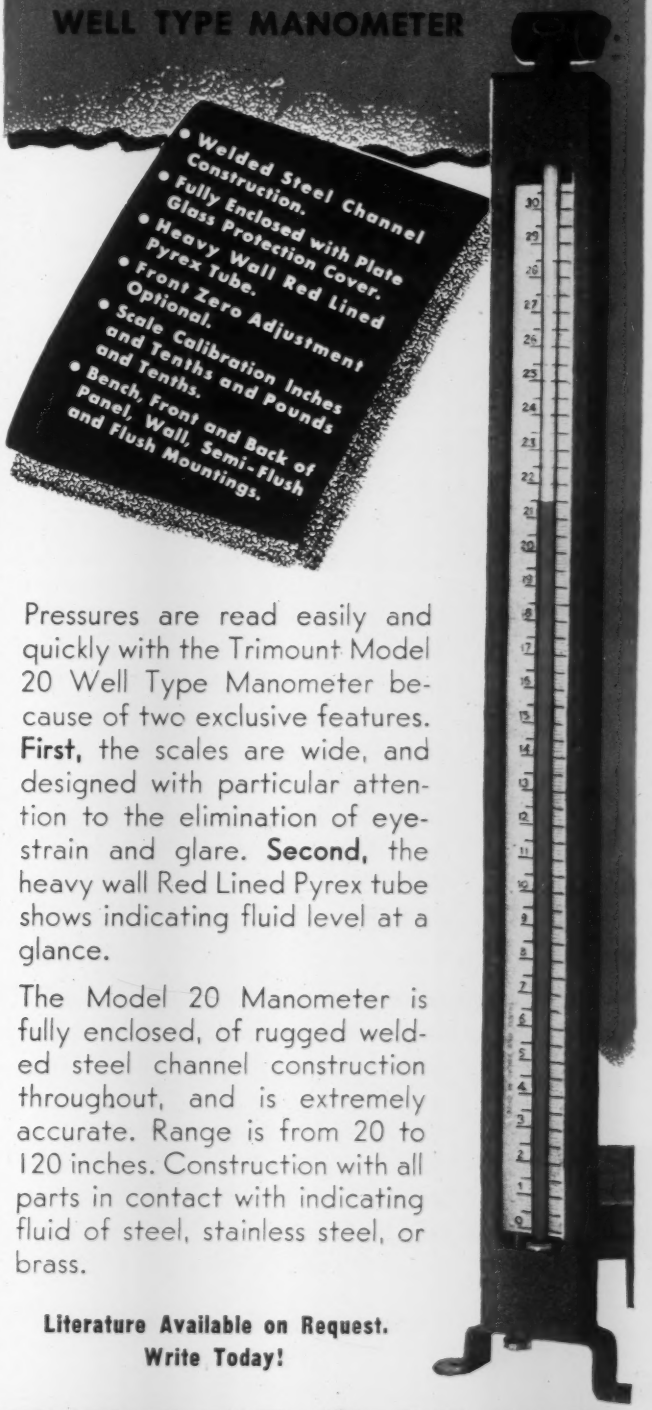


American Type Founders, Inc., Remote Control Division. Yardeny system Multiturn Selector switch and preset servomotor revolution control.

READ PRESSURES *Easily*

AND *Quickly* WITH THIS

WELL TYPE MANOMETER


• Welded Steel Channel Construction.
• Fully Enclosed with Plate Glass Protection Cover.
• Heavy Wall Red Lined Pyrex Tube.
• Front Zero Adjustment Optional.
• Scale Calibration Inches and Tenths and Pounds and Tenths.
• Bench, Front and Back of Panel, Wall, Semi-Flush and Flush Mountings.

Pressures are read easily and quickly with the Trimount Model 20 Well Type Manometer because of two exclusive features. **First,** the scales are wide, and designed with particular attention to the elimination of eye-strain and glare. **Second,** the heavy wall Red Lined Pyrex tube shows indicating fluid level at a glance.

The Model 20 Manometer is fully enclosed, of rugged welded steel channel construction throughout, and is extremely accurate. Range is from 20 to 120 inches. Construction with all parts in contact with indicating fluid of steel, stainless steel, or brass.

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termines the basic number of revolutions throu which the servomotor must revolve for any desired positi while the load dial is a vernier calibrated to 1/100th of revolution. The servomotor operating a gear reduction ca therefore, be positioned accurately to within 1/100th of a olution of the output shaft. Two sets of slotted screws adja nt to each dial, by proper manipulation, form the interloc which relates the six positions on the selector dial at th ight with the desired number of revolutions of the serv motor for each one of these positions. The servomotor, when set to any one of the desired positions, has a small amount of vershoot, which is quickly corrected, and it then returns to xactly the position desired.

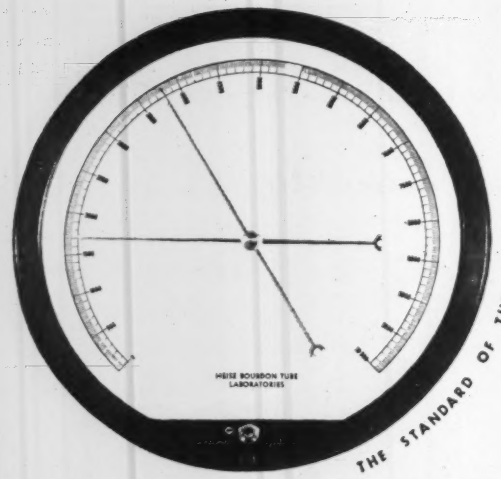
In place of the Multiturn Selector switch as shown, a push-button control station may be used.

A dual control is provided which is a combination of the continuously-variable control and the Multiturn Selector.

There is also available an Integrating Selector for positioning the servomotor to any one of a large number of positions with a relatively small number of remotely located push buttons, arranged to give a cumulative or integrated response of the servomotor in accordance with the number of buttons pressed at one time. Thus it is possible to obtain a total of 10,000 equally-spaced positions, each covering 10 revolutions of the load shaft, all controlled by 40 push-buttons, or four 10-point switches. These arrangements can be modified as occasion requires.

It is stated that the motors used do not have to be of any particular specifications, although the units currently applied are mostly subfractional commutating type motors. Other types of motors are adaptable. The motors incorporated within the selectors and servo units are in the category of those described previously as developed for aircraft instruments and control. The servomotor unit could be replaced with larger units fed directly through power amplifiers, or the small servomotor as a special form of relay could feed larger motors.

To be continued



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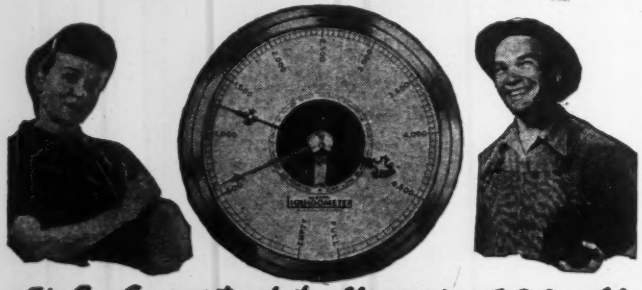

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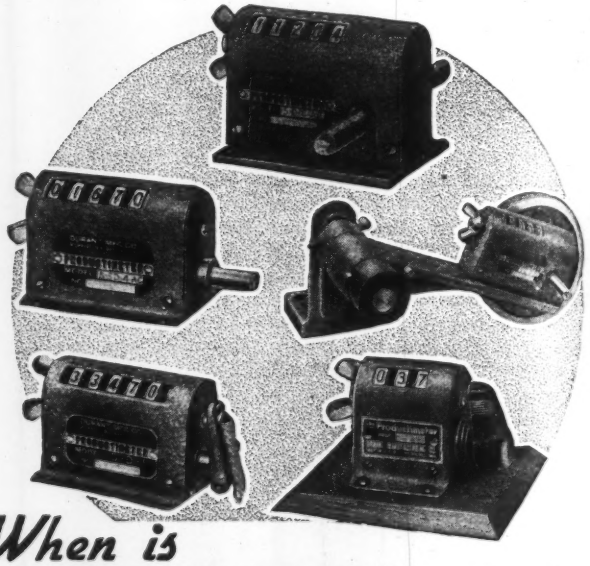

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Any day that you attack your production problems with the "D" line of Productimeters. It's a compact, firm, accurate line of counters to give you exact production count . . . by strokes or revolutions, in feet or yards, or by hand.

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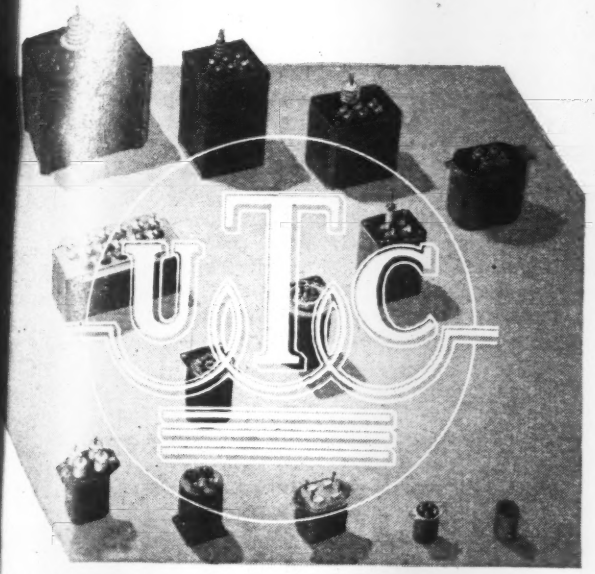

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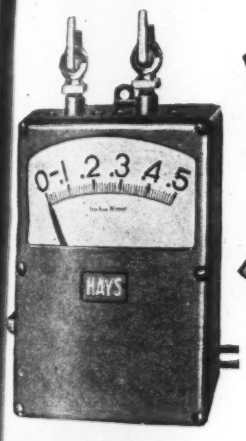

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- SAVES MONEY
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If you are confronted with the problem of not knowing when the collected dirt in your filters is of sufficient density to decrease operating efficiency, install a HAYS Air-Filter Gage. The HAYS indicator shows amount of air resistance at all times—tells when to renew filter element—eliminates guess work—can be made to sound alarm when resistance is excessive. Write for full information. Ask for HAYS Bulletin A-F G.

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● Salute! To our American women of industry—for their amazing skill, their stout-hearted stick-to-it-iveness! They are in the fight to the finish—and Kester Cored Solders are smoothing the way in hundreds of war plants throughout the nation.

● These uniform, high quality, flux-cored solders are fast, easy to apply, and *always* permanent—a "must" for speedier production. And like the "Chin-up" girls, Kester Cored Solders are *right* on the job 'til Victory.

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Instruments in the War Effort

Gun Locator

WASHINGTON. — Recent engineering advances have resulted in the development by the Signal Corps of improvements in sound ranging equipment which are proving important to American artillerymen in locating enemy gun positions.

Accurate sound ranging determines the location of an enemy gun by picking up the sound wave produced by the muzzle blast of the gun. Neutralizing counterbattery fire is then employed. This fire takes into account the point of explosion of our own projectiles and *the adjustment of our guns to coincide this explosion with the position of enemy guns.*

Sound ranging methods now in use require a number of special microphones connected with the central sound ranging system. The microphones pick up the signal (enemy gun fire or our shell bursts) and this is transmitted to the central station where they are photographically recorded by an oscillograph. The position of the enemy gun is determined from the differences of the times of arrival of the signal at the various microphones.

The new Signal Corps sound ranging set is less than half the size and weight of the equipment used by the Army at the outset of the war, and the photographic recording feature is being replaced by a dry recorder which eliminates the requirement for photographic chemicals.

The microphone array in sound ranging is often spread over a distance of 10,000 to 15,000 yards. Approximately ten miles of wire are required to connect the microphones to the recording station.

Soldier Invents Handy Foxhole Switchboard

WASHINGTON.—Private Russell H. Vogt, member of a Tank Destroyer unit attached to the Third Armored Division, has charge of the unit HQ switchboard. Finding it bulky to handle when enemy artillery or bombs forced him to seek the shelter of a foxhole, Pvt. Vogt decided to develop a handier model.

Knowing that the Germans have a small switchboard as part of their communications equipment, and feeling that two of these Nazi units combined would be about the right size for his "Foxhole Switchboard," Pvt. Vogt determined to acquire a pair of the German type. He did. Then, by carpentry and welding, he fastened the two frames together. The ten drops on the single German board were thus increased to 16, with room for a crank. This allowed for the separate handling of 16 outside lines by a complete switchboard, measuring only 15" square. He also installed in the frame a signal system powered by batteries, utilizing a German handset for phone use by the operator. The finished product resembles its American counterpart, but it is less than half the size.

A refinement developed by Pvt. Vogt is that upon the drop of one of the lines a tiny light connected to the battery switches on. This enables a sleeping man, awakened by the ringing of the bell, to pick out the line calling immediately.

However, the outstanding feature of the "Foxhole Switchboard" is its portability. It is easy to pick up and carry and true to its name, it fits nicely into a foxhole.

Giant Instrument Solves Difficult Mathematical Problems

SCHENECTADY, N. Y.—Mathematical problems which would take several years to work by conventional methods are now being solved in a few days at General Electric by use of a new type of differential analyzer, it was disclosed by the company here. This wizard robot, consisting of an interconnected system of shafts, motors and gears, employs mechanical elements for addition, subtraction, multiplication and division, and electro-mechanical elements for more complex functions. Practically all of the gears and couplings are removable and must be set up in a different arrangement for each new problem.

According to scientists, almost any physical phenomenon can be expressed in terms of differential equations. The G-E analyzer is fundamentally an instrument permitting rapid solution of such equations. Most important element of this new analyzer is a Polaroid photoelectric system* of unique design which G. E. developed. Fourteen of

*For description and diagram see *Instruments*, March 1945, page 144.

Like a cyclotron or a great telescope, this large mathematical instrument requires adequate instrumentation of its own: Note the two panel-boards at the upper right corner of this photograph.

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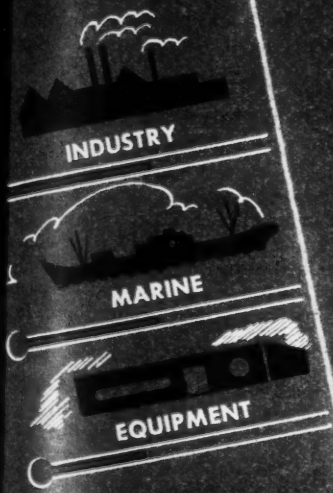

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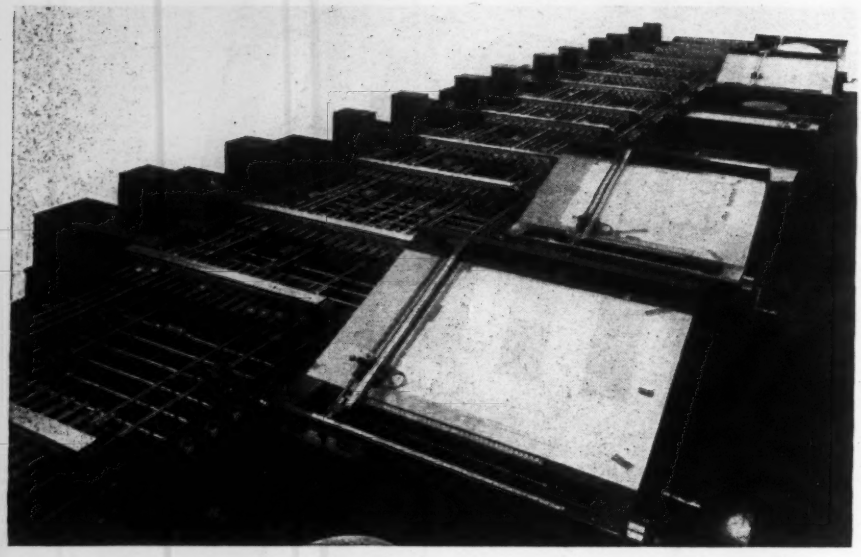

Oblique side view of the G-E differential analyzer, showing input-table and output-table assemblies.

these highly sensitive devices are installed on the machine, thus permitting the accurate and speedy solution of differential equations requiring as many as fourteen simultaneous integrations.

In appearance, the G-E analyzer resembles a long maze of shafts and gears with four input tables and two output tables extending to one side. When it is in use, the variables in the differential equations being solved are represented by the rotation of shafts. These are connected with mechanical pens on the output tables. As the shafts speed ahead to solve the equation, they move the pens which, in turn, plot an accurate curve in accordance with the mathematical quantities worked out by the continuous movement of the shafts. Interpreted correctly, this curve gives a graphic solution of the problem.

Before the analyzer is put into operation, the problem must first be set up on the machine. To do this, necessary equations are arrived at and various shafts and gears are interconnected so that all the quantities in the problem will be represented. Then, after the machine is set to work, technicians may grind into it by means of the input tables required mathematical functions, if more are needed, to obtain a final solution.

Differential analyzers of a type similar to the G-E device were first developed by Dr. Vannevar Bush, formerly of Massachusetts Institute of Technology. Later the Moore School of the University of Pennsylvania and M. I. T. made modifications and further improvements. When General Electric began construction of its analyzer, it patterned the mechanical part largely after those already in existence, adding some unique features of its own development. Most important of these was the photoelectric follow-up system used with the integrator. This improved the performance of the analyzer by attaining a shorter solution time with a greater degree of accuracy.

By making use of such mechanized mathematics, G-E engineers have been studying complex physical problems, many of which are related to the war. Applications made of the machine so far have included such problems as radar, hydrodynamic flow, rotating machinery, airplane stresses and speed governors. According to engineers, continuous availability of it in the future will result in greater knowledge and better understanding of many technical problems which were hitherto unsolved.

[EDITOR'S NOTE.—For a scientific discussion of operating principles see article "A Differential Analyzer" by Dr. V. Bush in *Journal of the Franklin Institute*, Oct. 1931, pages 447-488. An article describing this machine's applications will appear in the May 1945 *G-E Review*.—MFB]

Quartz Crystal Conservation

WASHINGTON.—A sheer accident is said to have spurred the development of modern-type, small-size quartz crystals, resulting in great savings in this critical war material, as well as in cost of production and in man hours. Before the start of the present war a radio "ham" in South Africa—a minister with a mechanical turn of mind—happened to drop and break a crystal which he had secured from a United States concern. The precious crystal broke into three pieces, two of them being small fragments no bigger than his thumbnail. Anxious to keep his set working if possible, he tried out the larger piece—and found that it functioned as well as the entire crystal had done. Amazed, he tried out the smaller fragments and found that they too worked successfully.

Hardly believing that his luck would hold, he wrote to the concern in the States ordering a new c stal, but re ported, parenthetically, t at the piece of his old one worked "a right." Thi letter, still on file with he compan which provided the large ze, old-styl crystals and now makes th tiny moder crystals by the million, a oused live discussion, even though th informatio contained in the letter wa not entire new. At that time there was an amp supply of quartz crystal for curre peacetime needs, but with the comin of war to Europe, and m re partic larly with the coming of war to Ame ica, the demand was stepped up prod giously. From that point on, the size the crystals used in radios ceased to b merely of academic or scientific inte est. It was a matter of life and dea to our fighting men and to our whol war effort.

The large bar-cut wafers, with a su face measurement of about one squa inch, were replaced as rapidly as po sible by tiny, thin crystals averagi less than three-tenths of a square in in area. Some of them measure on one-eighth square inch.

Small crystals, for Signal Corps r dio receivers and transmitters, require in turn, small holders, and the holde were standardized by reducing the num ber of different types to four. Ninety five per cent of all crystals procure by the Signal Corps are now in the four types of holders. And the thick ness of the new crystals runs fro 0.015" to 0.018".

Reduction in outside crystal sizes re sulted in the production of more plate per pound of raw material and also i the use of quartz of a size and qualit formerly considered non-adaptable. Th estimated saving of quartz in bul amounts so far to 1200 tons, and th estimated saving in cost is $24,000,00 Concurrently with this great economy standardization made possible fewe electrode sizes, simpler sockets, as we as holders, and fewer crystal specif cations.

The growth of crystal manufactur has been one of the fabulous chapter in American industry, brought abou largely by the demands of war in sup plying Signal Corps equipment.

Before Pearl Harbor there were som fifteen or twenty firms in Americ which could produce not over a hundre thousand units a year, and this by lab oratory methods that now seem clumsy War raised the military needs alone t millions of crystals yearly. It seeme impossible that the Signal Corps coul get them but they did get them—from plants that had been making lamp shades, coils, radio cabinets and in numerable other products. The whol industry has expanded three hundred fold in the past three war years, and while our original demands have been met and requirements will decrease somewhat as we approach vi tory in Europe, the quantities consumed will remain fabulous by comparison with pre-war consumption and manufacturing potential.

How to FIGHT "BULLS" that come from careless counting

Where production relies on miscounts and guesswork . . . "bulls" are bound to charge in and rip up production schedules . . . until mistakes are made impossible by up-to-the-minute operating records. So fit your war-production machines and processes with Veeder-Root Counting Devices . . . avoid delays, shortages and over-runs . . . improve interdepartmental co-ordination toward final assembly. See how you can make your work count to the utmost . . . by counting on Veeder-Root. Write.

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Measures only 8¼" x 6¼" x 3". Weighs just 2 lbs. 4 oz. Steel carrying case free.

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In actual field tests or in the lab., Dillon Dynamometers give *accurate* results every time. Measure tension or static loads quickly—*easily*. Compact. 9 different capacities—all same size, same weight. From 0-500 lbs. up to 0-20,000 lbs. Excellent delivery. Write today for technically illustrated catalog.

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- *Retardation Plates:* thin quartz plates for producing phase differences of the various wave lengths of light.
- *Polished Crystals:* special quartz crystals for supersonic applications.
- *Bertrand Plate:* a split phase quartz plate for more accurate determination of plane of the optical axis and the x-axis than can be accomplished with a single polariscope.

Look ahead . . . but look to VALPEY for crystals and specialties in quartz fabrication.

See us first when problems arise in the use of quartz. Our facilities, geared to war, will be equally well geared for peace. Our business is to apply the correct solution to your problem . . . just send us specifications and requirements.

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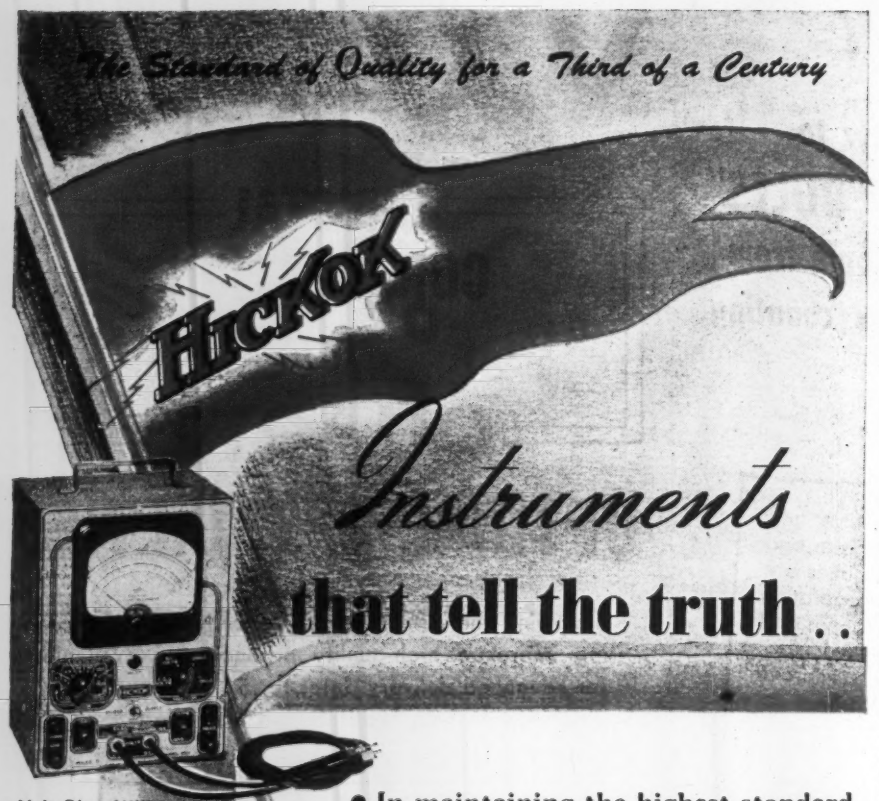
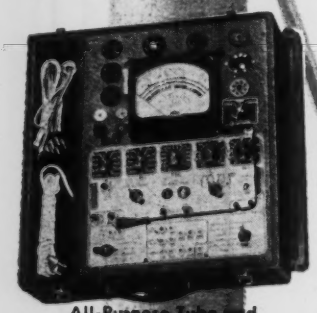
Crystal Corp.
HOLLISTON, MASS.

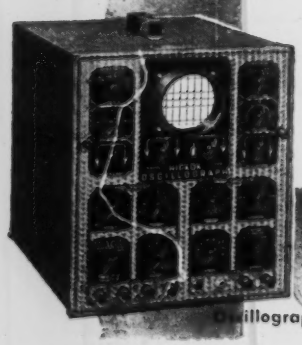


Volt-Ohm-Milliammeter



All-Purpose Tube and Set Tester

Signal Generator



Oscillograph

● In maintaining the highest standard of excellence the one and only HICKOK aim must always be the building of instruments that tell all the truth all the time. When quality is built up to a high standard instead of down to a price, the user has greater confidence in his work.

Whether you are selecting tube and set testers, signal generators, oscillographs, volt-ohm-milliammeters or any other service equipment, remember that the standard of quality for a third of a century has never been excelled. Having pioneered the major new developments and vindicated maximum accuracy and dependability, HICKOK equipment has been specified by the armed forces in both world wars. We are still bending every effort to speed the war program and trust it will not be long until we can again take care of your civilian needs with the service equipment that is held in highest esteem. Write for Radio Equipment catalogue.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
10519, Dupont Ave., Cleveland 8, Ohio

AUTOMATIC SWITCHING

Continued from Page 307

IV. Determination of Capacitor kvar Steps

If it is found that the capacitors should be automatically switched, the following steps are recommended in selecting the size and number of switching steps:

(a) Determine the maximum capacitor kvar permitted during light load condition without exceeding the upper voltage limits, to maintain desired power factor or to keep the reactive kvar demand within desired limits.

(b) Next determine the maximum capacitor kvar that can be switched in one operation without exceeding the permissible voltage limits, kvar demand or change in power factor.

(c) The difference between the total capacitor kvar installed and the capacitor permitted during light load determines the total capacitor kvar to be switched.

(d) The minimum number of switching steps is the ratio of the total capacitor kvar to be switched to the maximum capacitor kvar that can be switched in one operation without exceeding permissible limits.

For practical purposes the voltage drop can be determined from the kilowatt load component flowing through the resistance of the circuit plus the kilovar component flowing through the reactance of the circuit. The voltage rise produced by the capacitor is the product of the circuit reactance ohms and the change in kilovar load amperes provided by the capacitor. When calculating voltage rise produced by the capacitor above an existing voltage level, the non-linear variation of exciting kilovars drawn by motors, transformers, etc. should be given due consideration. If the voltage level is high, the exciting kilovars load may increase rapidly with small increase in voltage and should be taken into account in arriving at the net kilovars. It should be also kept in mind that the capacitor kvar varies as the square of the voltage for a given rating. If the voltage level is moderate and steps are taken to permit only a small change in voltage, the non-linear variation of exciting kilovars may be of no consequence and may be disregarded. If this is the case, the voltage rise produced by the capacitor is the product of the circuit reactance ohms and the capacitor current.

$$\text{Percent voltage rise} = \frac{\text{Capacitor kvar} \times \text{circuit reactance}}{10 \times (\text{line kilovolts})^2}$$

(Circuit reactance in ohms.)

Not only are capacitors applied to improve circuit voltage, increase system capacity, reduce kvar demand and improve power factor but they are also used to reduce power costs. In the final analysis they are chosen because they are more economical than other methods of obtaining improved circuit performance or reduced power costs.

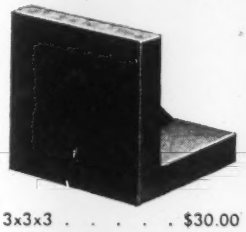
SCHERR SURFACE PLATES — ANGLE IRONS

Hand scraped Flat to .0002"

Scherr surface plates can be depended upon as the basis for real precision work. Handscraped flatness is guaranteed to .0002". Maintained rigidity is assured by heavy ribs, so arranged as to allow adequate clamping surface. Three point support affords solidity. Eight sizes from 9x12 in. to 24x36 in. Also available planed only.

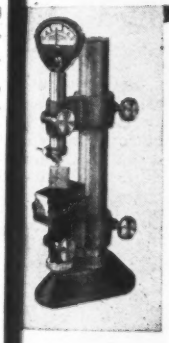
Scherr angle irons are hand scraped on all bearing surfaces and are guaranteed flat and square within .0002 in 6 inches. Seven sizes, from 3x3x3 in. to 12x16x14 in. Order direct or write for complete data and the Scherr catalog of precision tools.

9x12	$35.00
9x14	39.50
12x12	43.00
12x15	56.00
12x18	68.00
18x24	133.00
24x24	180.00
24x36	275.00



3x3x3	$30.00
4x4x4	35.00
5x5x5	40.00
6x6x6	45.00
8x10x12	75.00
9x12x10	85.00
12x16x14	130.00

GEO. SCHERR CO., Inc. 199-A LAFAYETTE STREET NEW YORK 12, N. Y.



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SENSITIVE
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Positive, Dependable Repeat Readings

Made in 4 Sizes

Complete elimination of friction, lag, and backlash insures positive, dependable, repeat readings. Pointer responds instantly to the slightest movement of measuring tip; no swinging past true reading, no waiting for pointer to come to rest. No lights or electromagnets, no warm-up period required. No electrical connections, can be readily moved to different locations. GRADUATED: .0001" to .00001"; .001 mm to .0002 mm.

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Boiler Meters Reduce fuel costs, lessen maintenance and outage, lower standby costs, and add capacity. They indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature.

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Multi-Pointer Gage

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Control Systems Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-14

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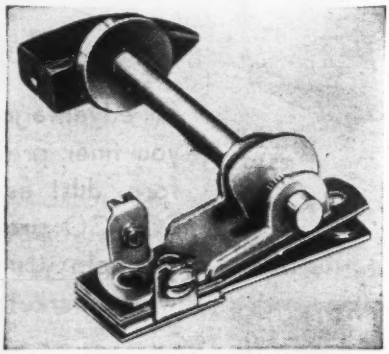
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Thermostatic Switch

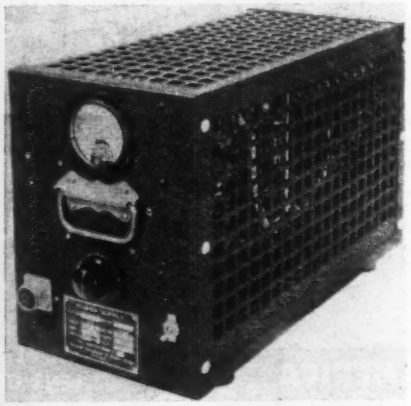
New Dual Cam-Adjusted Thermostatic switch is described as a compact versatile unit that can be used for either or both a thermostat and a manual switch. It obviates the need of an additional on-and-off



switch and permits instant adjustment of the thermostat. It is suited for mounting on bottom of electrically-heated equipment such as glue pots, hot plates, etc. where manual on and off knob is desired. Knob can be located any distance from thermostatic element by lengthening cam shaft. Pointer on knob can be set at any desired temperature for thermostat to control heating element. Unit is available in three adjustable temperature brackets: 50° to 300°F. 50° to 450°F., and 50° to 700° F. Rated at 1500 watts, 115-230 volts a.c. Convenwas absolutely no moisture penetration." *George Ulanet Co., 88 East Kinney St., Newark, N. J.*

Regulated-voltage Power Supply

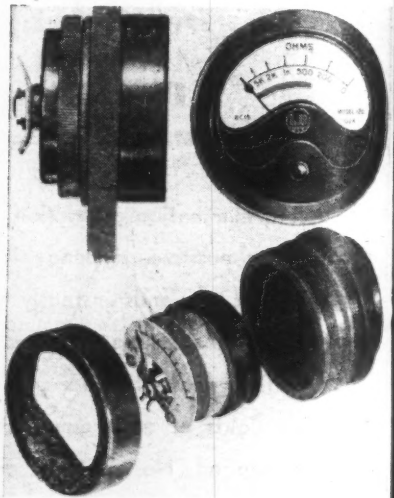
New "FTR-3128-S" power supply is a compact, light-weight, multi-purpose rectifier unit for use in a wide variety of applications where closely regulated direct-current is required. It has been primarily designed for use in aircraft manufacture



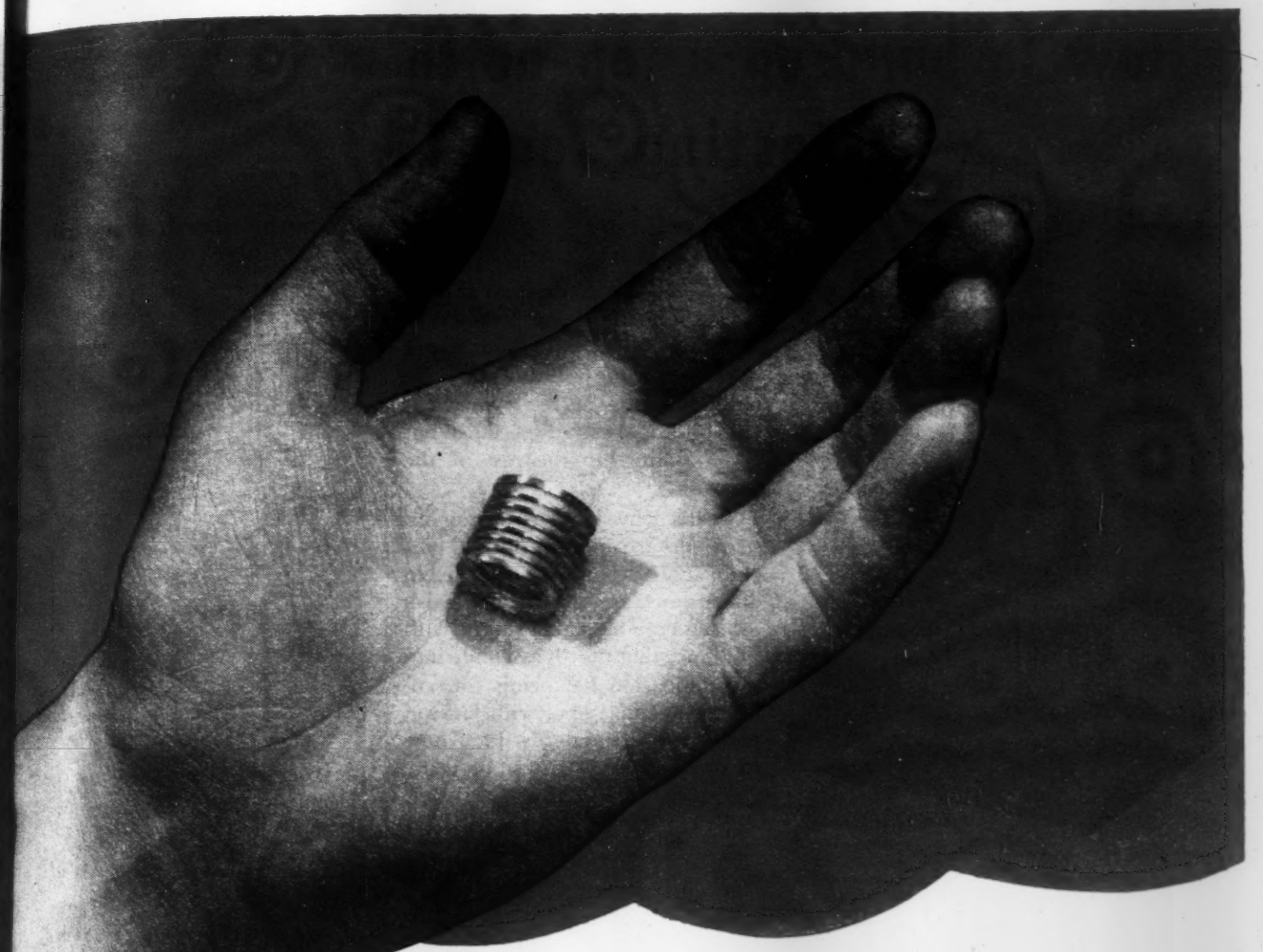
and maintenance, for testing instrumenta inverters, controls, and radio navigational and communications equipment. It can be used in numerous other applications where an easily-portable well-regulated d-c. power supply is required. New unit utilizes Federal Selenium Rectifier and operates from single-phase a-c. input of 115 volts, 58 to 62 cycles, providing d-c. power up to 10 amperes, continuous duty, at any selected voltage between 22 and 30 volts. Output voltage is automatically held constant within ±0.5 volt regardless of load variation from zero to 10 amperes, or a-c. line voltage fluctuations of 105 to 125 volts. Ripple voltage is limited to approximately 5%. New feature is ability of unit to maintain its performance with line frequency changes which exceed those of commercial power lines. An ON-OFF switch, 0-30 scale d-c. voltmeter, and d-c. output terminals are mounted on front panel. An 8-foot rubber-covered cord with metal-sheathed plug is provided for a-c. input connection. Entire equipment weighs approx. 74 lbs., is enclosed in a black medium-wrinkle finish cabinet, 11¼" × 8" × 16". —*Federal Telephone and Radio Corp., Newark, N. J.*

Miniature Electrical Indicating Instrument

New "Model 120" is a hermetically-sealed ring-mounted 1½" indicating instrument built to A.S.A. specifications, is said to be the smallest available indicating instrument "capable of performing a full-scale task



in a variety of applications, present or postwar." It can be immersed in water at a depth of 30 feet for seven days without harm to its mechanism. In mounting, flange is sealed to panel by a gasket. Case including terminal studs is completely waterproof: if glass breaks, equipment remains waterproof. Built of corrosion-resistant materials, instrument has a black anodized finish. Instrument flange may be mounted



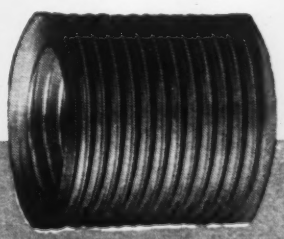
MIGHTY MITE!

THAT TINY OBJECT there in the man's palm—that's a Sylphon Bellows. When fitted with proper heads and charged with a thermo-sensitive liquid it becomes a thermostat—a powerful little "motor" deriving its power from changes in temperature of the confined liquid. Without the liquid charge, the assembly could be used as a pressure "motor." In either case the developed power could be employed to "make" and "break" electrical circuits, open and close valves, dampers, etc. —in fact its usage is virtually without limit.

This particular Sylphon Bellows is only ¾ inches in diameter yet it's so rugged that it can withstand pressures up to 315 pounds per square inch. Other sizes and types available for even higher pressures.

Together with its larger and smaller companions, this mighty mite is ready to fit into your post-war plans —simplify and improve existing designs—possibly be the key to revolutionary new developments.

Write for the complete story—Bulletin No. JE-1300 contains valuable data which should be useful to every engineer. A copy will be sent upon request.

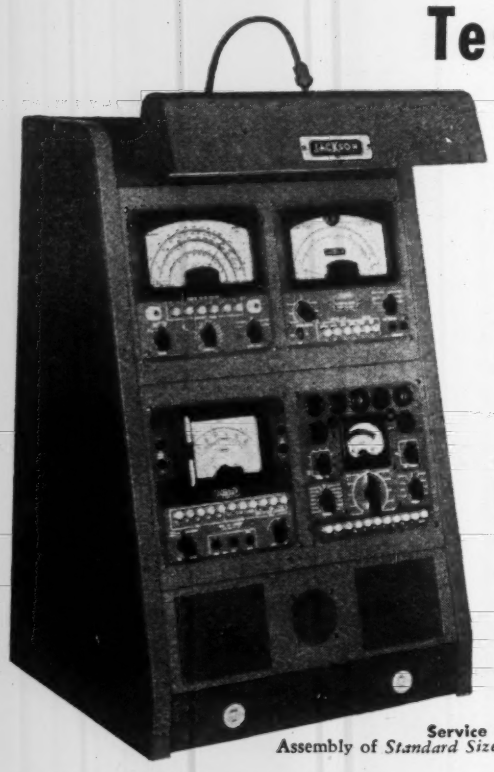
FULTON  **SYLPHON**

TEMPERATURE CONTROLS BELLOWS . . . BELLOWS ASSEMBLIES

THE FULTON SYLPHON CO., KNOXVILLE 4, TENNESSEE

Canadian Representatives, Darling Brothers, Montreal

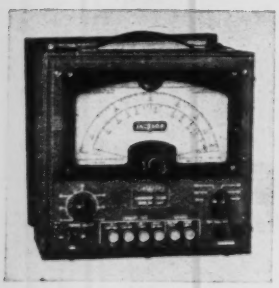
How to build up a top-notch Testing Team!



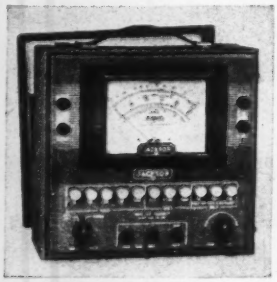
YOU don't have to do it all at once—just plan ahead and make every purchase count when you buy a new instrument. Then you'll be building up a perfectly-matched testing team—each a specialist, but each backing up the rest of the team.

That's why Jackson testing instruments are not only built to pinpoint accuracy—but are matched in dimensions, appearance and finish too. You can buy them singly, with assurance that they'll assemble into a combination balancing convenience and appearance with Jackson performance standards. Plan now to own a complete testing team.

Service Lab
Assembly of *Standard Size* Jackson Instruments



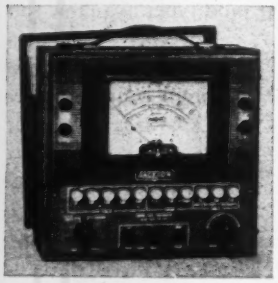
Condenser Tester
Model 650A—Measures Capacity, Power Factor and Leakage



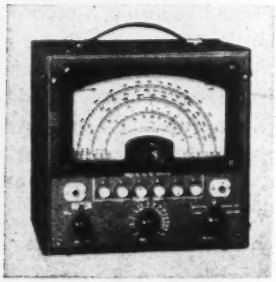
Sensitive Multimeter
Model 642—20,000 ohms per volt—complete ranges

Electronic Multimeter
Model 645—A new Jackson instrument of advanced design

Tube Tester
Model 634—Uses exclusive Jackson "Dynamic" Test Method



Multimeter
Model 643—1000 ohms per volt. Push key range selection



Test Oscillator
Model 640—Accurate to ½%, covers full frequency range

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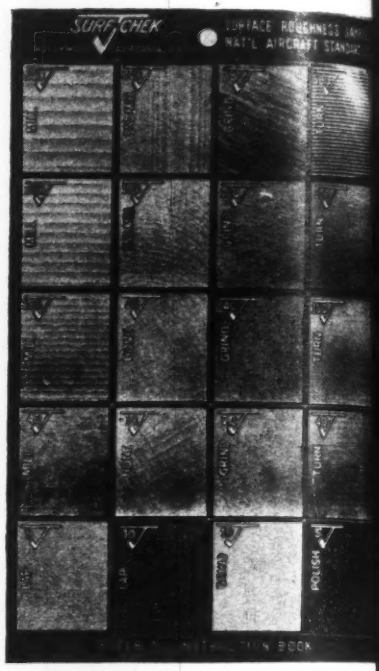
on any steel or Bakelite panel between ⅛ and ¼". A waterproof gasket is supplied for sealing to panel. New "Model 120" is rim mounted to obviate need for mounting holes or screws, is available in a wide variety of ranges including highly sensitive micro ammeter or microvoltmeter specifications. — *DeJur-Amsco Corp., Northern Blvd. & 45 St., Long Island City 1, N. Y.*

Surface-finish Standards

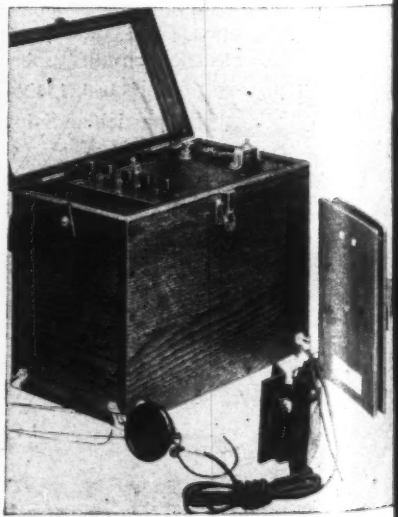
New "Surf-Chek Roughness Standards" a development of J. A. Broadston at North American Aviation, Inc., is a kit containing a 65-page educational text bound to a



of 20 replicas of machined surfaces prepared by turning, grinding, milling, honing, lapping and polishing, which vary in roughness from 500 to 5 microinches. Replicas are molded into a 5" × 7" plastic plate through use of precise die inserts. Kit includes also a symbols template for draftsmen and machinists. — *Surface Check Gage Co., Hollywood 28, Calif.*

Buried Pipe and Wire Detector

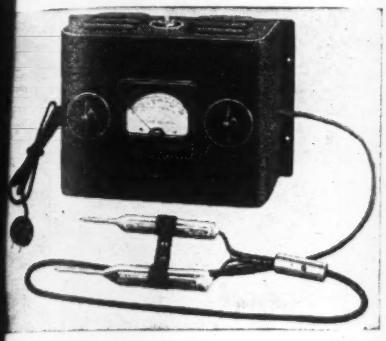
New "Model A Cable and Pipe Locator" will be highly useful to anyone faced with necessity of finding old pipes or wires that may have been buried for many years and



which records have been lost. It is a table set, measuring 13" × 7½" × 11" weighing 14 lbs. (less Detector Coil Neutral Exploring Coil and Receiver). has a lamp circuit for checking all connections after the test has been set up. It especially valuable for checking depth of le at river crossings or for determining ether or not a service pipe is below frost after a street has been lowered or reded. Set is furnished with a detector coil a neutral exploring coil. Built-in spirit enables operator to maintain level for best accuracy. Set comes in handsomely-shed sturdy hardwood cabinet, complete h high-quality earphone receiver, ready use.—*W. C. Dillon & Co., Inc., 5410 W. rrison St., Chicago 44, Ill.*

Vacuum Gage

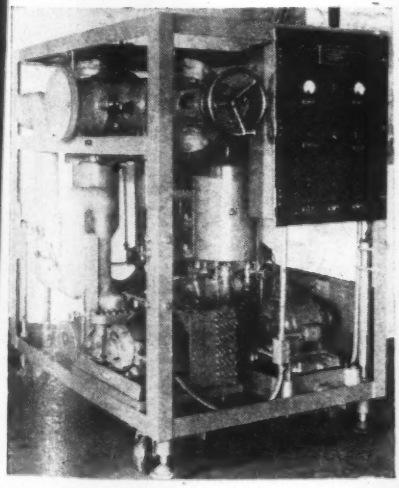
New "Tru-Vac Model 18" is a new type vacuum indicator which operates directly m any 110-120-volt a-c. line and is said fill an important need for manufacturers

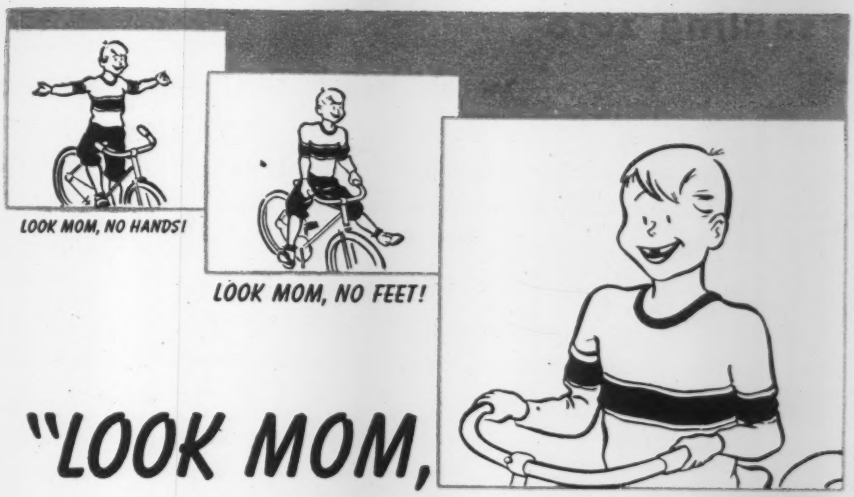


a wide variety of products which require ntinuous or occasional vacuum readings their processing. It is scaled to read essures of a vacuum system from 0.25 to 0 microns and is accurate to ± 2% roughout scale, with constant voltage in-t. Engineered on the Pirani principle, new ge is unaffected by change in barometric essure. Adjustment may be made to pro-ide line voltage compensation. Indicator nd controls are contained in a metal case easuring 8" × 6" × 3½". Instrument is onvenient to attach to the vacuum system; oreover, indicator and controls can be ounted at a distance from point at which easurements are to be taken.—*Continental Electric Company, Geneva, Illinois.*

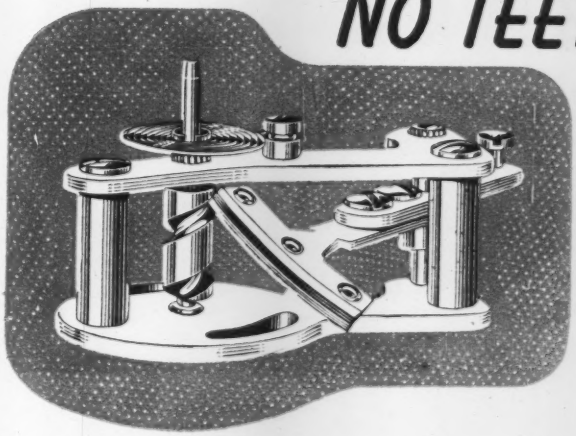
"Package-type" High-vacuum Pumping System

New "Type PS" complete high-vacuum systems, in small compact units for direct connection to system to be evacuated, supplement makers' line of diffusion pumps,





"LOOK MOM, NO TEETH!"



This is no joke. To Mom it is serious. And to you also "no teeth" is an important matter, if you use pressure gauges. Now you can get Certified Gauges with the new, patented Helicoid Movement and that means no teeth to wear out.

After serving in the Navy for several years, Certified Gauges are now available to industry for prompt delivery.

If you've had gauge trouble due to movements wearing out or getting sticky, investigate Certified. Try one on some really tough service. See for yourself how much longer they wear and remain accurate. Ask the man who uses them.

Only Certified Gauges are made with the Helicoid Movement. All Certified Gauges are guaranteed accurate to within ½ of 1%. Send for catalog today.

Certified GAUGE
AND INSTRUMENT CORP.
34-18 Northern Boulevard — Long Island City 1, New York

"sealing zero"

with high vacuum seals

ROTARY BELLOWS SEAL

A ruggedly built turning shaft to introduce rotary motion into a high vacuum system. Bellows construction permits positive vacuum seal. No packing whatsoever is used.

Also available are other types of vacuum seals. These include:

high voltage vacuum leads . . . To introduce into vacuum systems voltages up to 15,000 volts.

universal vacuum seals . . . For use in attaching glass or metal tubing to vacuum systems. Designed to permit quick detachment of tubing.

binding post seals . . . . . Iron and constantan thermocouple binding post vacuum seals designed for various plate thicknesses.

adapter seals . . . . . To introduce tubing into a vacuum chamber for passage of water, gases, etc. through the system.

Vacuum ENGINEERING DIVISION

NATIONAL RESEARCH CORPORATION

BOSTON 13, MASSACHUSETTS, U.S.A.

High Vacuum for Industry

On request we will be pleased to send you our Bulletin VS-1 on Vacuum Seals.

high-vacuum valves, manifolds and gages. New units are available in various capacities and ultimate vacuum, consisting of mechanical forepump, diffusion pump, high-vacuum valves, gages, and control panel. (Mechanically-refrigerated traps built-in on special order.) "PS" systems are simple to operate and obviate the need of setting up high-vacuum pumping systems. One connection only is necessary. Unit is fully automatic and incorporates various safety and protective features. Vacuum conditions are indicated continuously on control panel, and recorders may be used. Chassis is of rigid construction and may be mounted on casters.—*Vacuum Engineering Div., National Research Corp., Boston 15, Mass.*

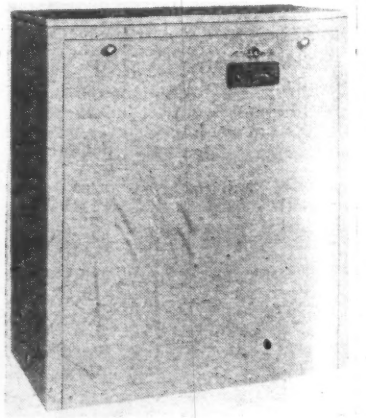
Bottle and Can Counters

New "HF" Series Bottle and Can Counters supersedes former "F" models. Among improvements is use of "H" type counter with modern oilless bearings, curved louvered

window for quick reading of figures, molded plastic number wheels, legible black figures on white background, die-cast base with dust-tight metal cover, rust-proof construction, steel stamping mounting plate and grey baked enamel finish. New "HF" series is available in either 5- or 6-figure capacity, counting to 99,999 or 999,999, and equipped with a 6-point star wheel for counting bottles, and a 4-point star wheel for cans.—*Durant Mfg. Co., 1914 N. Buffum St., Milwaukee 1, Wis.*

Coolant-temperature Controllers

New "packaged units" are especially designed for controlling the temperature of coolants and cutting oils. Under present high-speed operating conditions, cutting oils

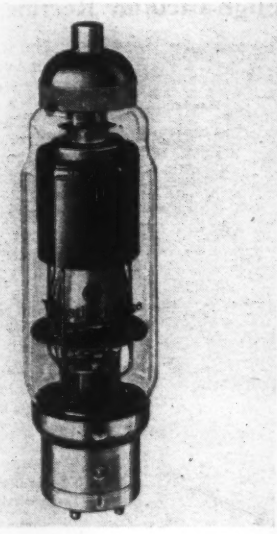


which lack sufficient cooling properties cause variations in size, shape and location tolerances of workpiece and of the machine itself. These variations may necessitate frequent machine adjustment to hold location and tolerances. New "packaged" cooling units are said to represent a system of controlling the variables caused by coolants and cutting oils which exist in many production lines. It is said that uniform temperature condition, once established, can be maintained throughout the year. Cooling

nits remove a constant volume of heat qual to that being generated, thus removg heat rapidly enough from point of cut. Maximum flexibility of operation is said to e obtained by installing "packaged" cooling in connection with each machine tool. n addition to being compact and self-contained, system is automatic and simple to perate. Its design lends itself to rearrangeent of production lines, and is adjustable suit individual machine.—*Airtemp Division of Chrysler Corp., Dayton, Ohio.*

15,000-volt Thyratron

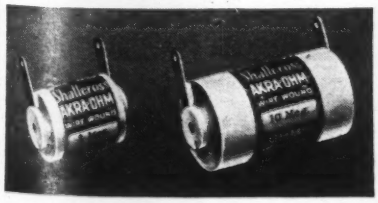
New "WL-678" 15,000-volt Thyratron ower control tube provides split-cycle conrol of high power for r-f. heating units, adio transmitters, etc. It makes possible



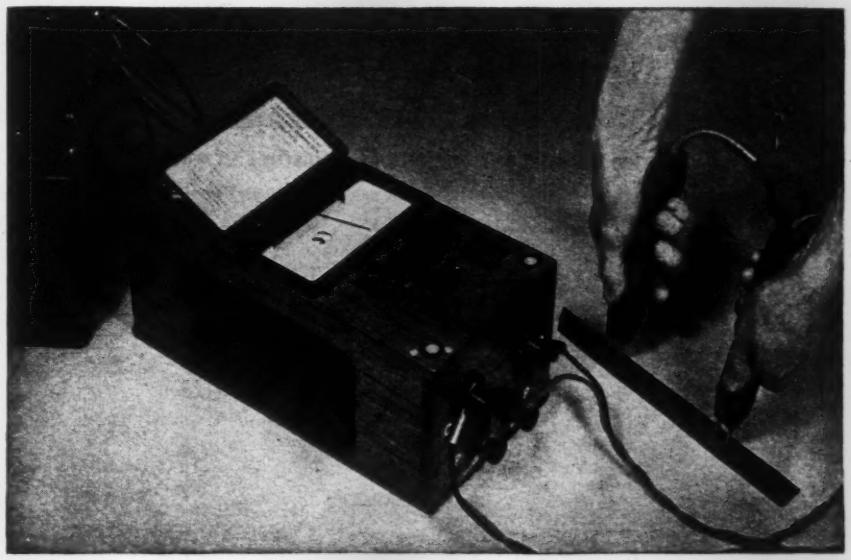
moeth and instantaneous power control rom 0% to 100% load; simplified autoatic load control; high-speed automatic verload protection; low space and weight equirements and low control power requirements. This new grid-controlled mercury apor rectifier tube is designed to combine he high voltage characteristics of a Kenotron, control qualities of a Thyratron and fficiency of a Phanotron. General characeristics: filament voltage 5.0 volts; filament current 7.5 amperes; filament heating ime (minimum) 1 minute; typical control ias at rated voltage, —50 volts (55°C.) and —75 volts (50°C. max. thg). Anode voltage, eak 10000 (55°C.) and 15000 (50°C.); node current, average, 1.6 amperes; anode urrent, peak, 6 amperes; temperature ange, condensed mercury, 25 to 55°C.—*Lamp Division, Westinghouse Electric Corporation, Bloomfield, N. J.*

Hermetically-Sealed Resistors

New "No. 1100 Series Hermetically Sealed Accurate Fixed Wire-Wound Resistors (patnt applied for)" are hermetically-sealed nits impervious to moisture, fungus, vibraion and rough handling. They are constructed without glass, without fragile "floating"



r stud-locked resistance elements, and without ferrule terminals or caps which give ise to possibility of strain and consequent ealing failure. In size, new "No. 1100 eries" compares favorably with corresponding BX Process impregnated "Types



Splits an Ohm into a Million Parts

"DUCTER" LOW RESISTANCE OHMMETER

measures current-carrying ability of circuit breakers and switches down to .000001 ohm

Built to "stand the gaff" of field use . . . reads directly by pointer deflection . . . so accurate and reliable that your laboratory can readily give O. K. . . . SUCH is the Ducter Ohmmeter, a rugged "Megger" type instrument that is now finding important uses in circuit breaker maintenance and for testing other low resistances that today *must* carry their rated loads.

The Ducter operates from a storage battery, and by applying test leads, one can actually *see at a glance* the condition of a vital part of a circuit breaker, switch or joint—namely—its contact resistance. The Ducter Ohmmeter does for measuring conductor resistance what "Megger" Instruments do for testing insulation resistance.

Write for illustrated descriptive Bulletin 1635-I.

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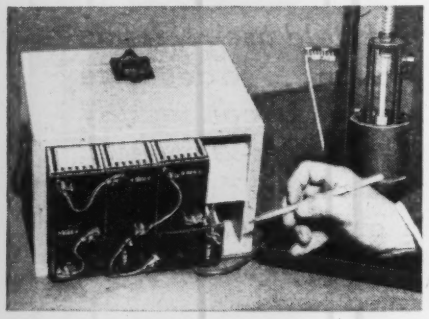
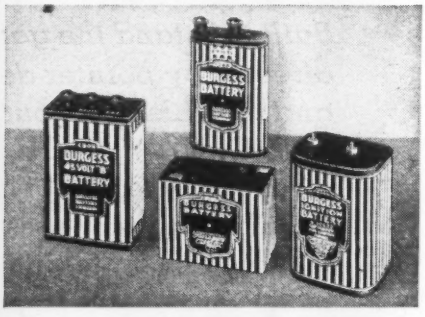
PORTABLE POWER PROBLEMS

THIS MONTH—TAG-HEPPENSTALL MOISTURE METER

MAJOR TOBACCO COMPANIES rely upon Tag-Heppenstall Moisture Meters, powered by Burgess Industrial Batteries, for two important time-and-money saving features. First, tests of moisture content are made to determine the purchase price of raw tobacco. Next, rapid tests during cigarette production help manufacturers maintain tobacco moisture at the level required for efficient processing.





MOISTURE METER READINGS of resistance, temperature and pressure are checked against a standard chart to quickly establish exact tobacco moisture. For test and control instruments Burgess Industrial Batteries meet every requirement—they are recognized as the standard of quality for all commercial uses. Although urgent war needs limit production, your Burgess distributor will make every effort to supply you with the batteries you require.

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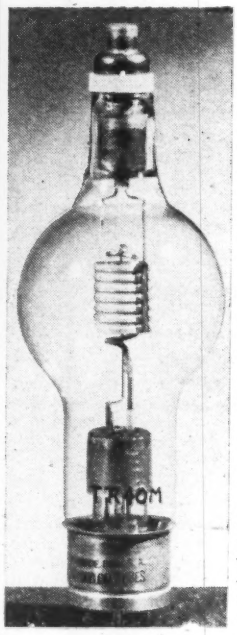
190 and 196 Akra-Ohm Accurate Fixed Wire Wound Resistors." Moreover, they utilize standard mounting facilities. They are at present available in two designs and in all resistance values from 1000 ohms to 10 megohms. Winding element and outer shell compose an integral unit without internal leads or floating wires, thus affording complete protection even against severe vibration. Positive solder-sealing without use of ferrule caps or glass drawing protects against moisture and fungus. Windings are of standard noninductive pie type. Terminals are of the standard solder lug type. Mounting is accomplished by means of standard mounting hole, thus permitting standard mounting throughout any piece of equipment—*Shallcross Mfg. Co., Collingdale, Penna.*

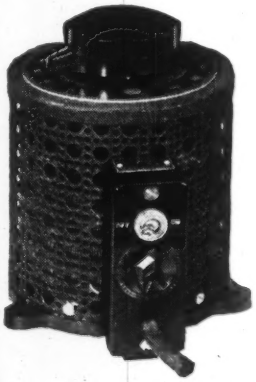
High-vacuum Rectifier Tube



New "TR-40M" high-vacuum half-wave rectifier tube is 9¾" high with a maximum diameter of 3 15/16". It is equipped with a 4-pin jumbo (50-watt) base and the glass is Nonex. Filament is thoriated tungsten for long life. Plate lead is at top and filament leads are brought out to pins Nos. 2 & 4. Electrical characteristics: Filament power, 5.0 volts at 10.5 amperes; peak forward volts, 25,000; peak inverse volts, 60,000; average plate current, 0.25 amperes. Special design features are said to insure complete safety against voltage breakdowns.—*Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill.*

Variable-voltage Transformers

New "Type 116" and "Type 216" are added to maker's standard line of "Powerstats" to meet demand for a lightweight, ruggedly-constructed variable transformer

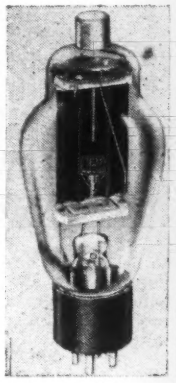


in the 1-kva. range. These new models are said to possess highest output current rating for equivalent panel mounting dimensions and to have features found in no other variable transformer of comparable size. Extra-large aluminum brush heat radiator is combined with a new type of brush pressure adjustment spring to assure low brush temperature rise and reduced probability of damage from sudden overloads. Through ingenious design of core and coil and use of all-aluminum mechanical construction, weight is held down to 9 lbs. including

protective screening and totally-enclosed terminal box with input cord and plug, outlet, and "on-off" switch. When units are supplied less screening and terminal box, weight is 7.5 lbs. Designated as "U" types, uncased models are intended primarily for rear-of-panel mounting. Convenient connectors on a Bakelite terminal strip provide for easy installation in any low power circuit. "Model 116" operates on single-phase 115-volt input to deliver a variable output voltage from 0 to 135 volts with 1.5 amperes available at any brush position. "Model 216" has twice the voltage rating and a current rating of 3.0 amperes. By mounting the single units in tandem, different voltage and current ratings are obtained.—*Superior Electric Co., 422 Laurel St., Bristol, Conn.*

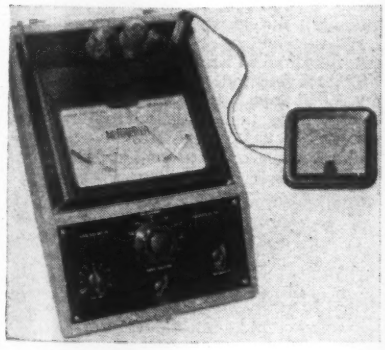
High-voltage Rectifier Tube

New "Type 3B 27" rectifier is said to fill need for a high-voltage rectifier of rugged construction suitable for industrial and mobile transmitter use. It is a high-vacuum type applicable where disturbance from power supply must be kept to a minimum. Unusual construction features include double heaters and cathodes, ceramic spaces for low leakage and extra-heavy supports for immunity to severe vibration and mechanical shock. Ratings are: Peak inverse voltage 8,500; peak plate current 0.6 amps.; average plate current 0.150 amps. Four tubes in full bridge deliver 5415 volts d.c. to filter with 6000 volts total input. Filament draws 5.0 amps. at 2.5 volts. Base is medium four-pin bayonet. —*Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark 4, N. J.*



Multi-range Electrical-instrument Testing Set

New "Marion multi-range Metertester" is designed especially to improve production rates of inspection departments, but is said to have a degree of accuracy to permit its use in all laboratories where instruments are used. It has a self-contained regulated power supply and control equipment for use on 110-volt 60-cycle a.c.; a stepless vacuum-tube voltage control; an 8½" mirror scale standard instrument and a decade of 0.1% accurate wire wound resistors. Range is 25 microamperes full-scale to 10 milliamperes full-scale and 0-100 volts full-scale. Overall accuracy is better than 0.5%; basic instrument sensitivity is 10 milliamperes. Among construction features are sapphire jewels,



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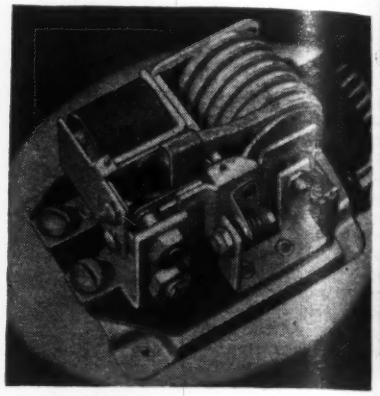
Vibration- and Shock-resistant Reverse Current Relay

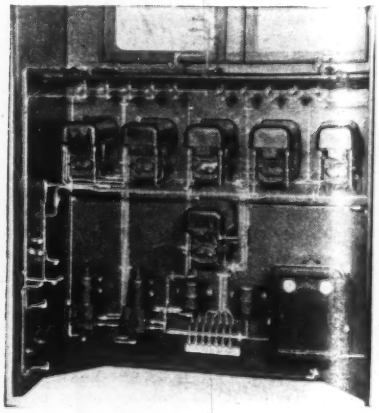
New "Type 9100" reverse current relay, originally designed for special use on auxiliary engine-driven power generators in Army tanks and airplane bombers, is said



to be equally effective for any "tough" low-voltage d-c. application and to assure dependable operation on either stationary or mobile equipment. Design incorporates a magnetic latch which prevents accidental closing of armature and contacts due to vibration up to 10 *G*, or heavy shock. Contacts rated 100 amperes at 30 volts d. c. maximum. Dimensions—width 4 1/16", depth 3 7/16", height 2 7/16". Approximate weight, 1.6 lbs. This R-B-M Reverse Current Relay without magnetic latch ("Type 9000") is also available for use where severe vibration and shock are not encountered—in sizes as low as 300 watts at 6, 12, 18, and 24 volts d. c.—*R-B-M Mfg. Co., Div. of Essex Wire Corp., Logansport, Indiana.*

Prefabricated Boiler Control Panels

New prefabricated boiler control panels include all necessary connecting piping and electrical wiring for the operation of metering equipment and boiler control systems. are factory-tested by experienced instrument mechanics, are said to save installation time, to insure use of suitable materials, to reduce total installed cost, and to present a neat, pleasing appearance. All



ng and wir necessary for operation stalled as a nit according to a coordid plan inste of as piecemeal operas by variou contractors in the field. ll units such as valves, relays, switches, al lights and certain light-weight inments are mounted and connected ready service. Heavy instruments or instruts having delicate mechanisms are ped separately; but cutout spaces, drilland all necessary connections are pro- so that their installation in the field uick and easy. Connecting piping and trical wiring are brought to convenient inals which are carefully tagged.—*ley Meter Co., 1050 Ivanhoe Road, Cleveld 10, Ohio.*

Snap-action Switch

New "Snapit" switch is a small momenpush-button snap-action switch. Its phe body is 7/8" in diameter by 1 7/8" high easured from top of push-button to end of solder lugs). Switch is mounted by a 5/8-32 bushing, 7/16" long and held securely by two mounting nuts. Fixed contacts, of fine silver overlay on phosphor bronze, are threaded and are held securely in place, electrical connection being made by brass screws which also hold and secure the two solder lugs. The moving contact which bridges the two fixed contacts is also fine silver overlay on phosphor bronze. Contact gap is 0.040" on each contact; total gap which breaks cir- it is 0.080". Snap action principle assures t make and break as well as a contact essure of approx. 35 grams, making the itch practical for use on direct current. itch operates on a 0.0625" movement of push button and carries a current rat- of 10 amperes at 115 volts a.c. and 2 peres at 115 volts d.c. Manufacturer tes that when switch is operated, a de- ed click is heard as well as felt, indiing that switch has operated; this is adntageous on test equipment and similar plications where verification of action is sired. Normally-open single-pole switch is dicated by a red push button; and a black sh button indicates a normally-closed sine-pole switch.—*Grayhill, 1 North Pulaski oad, Chicago 24, Illinois.*

Polyphosphate Comparator

New "Poly Phosphate Comparator" prodes a simple, rapid and accurate method analysis of low concentrations of the poly glassy) phosphates, such as hexameta, yro, septa, etc. A complete determination quires twenty minutes. After conversion, o reagents are added separately and the

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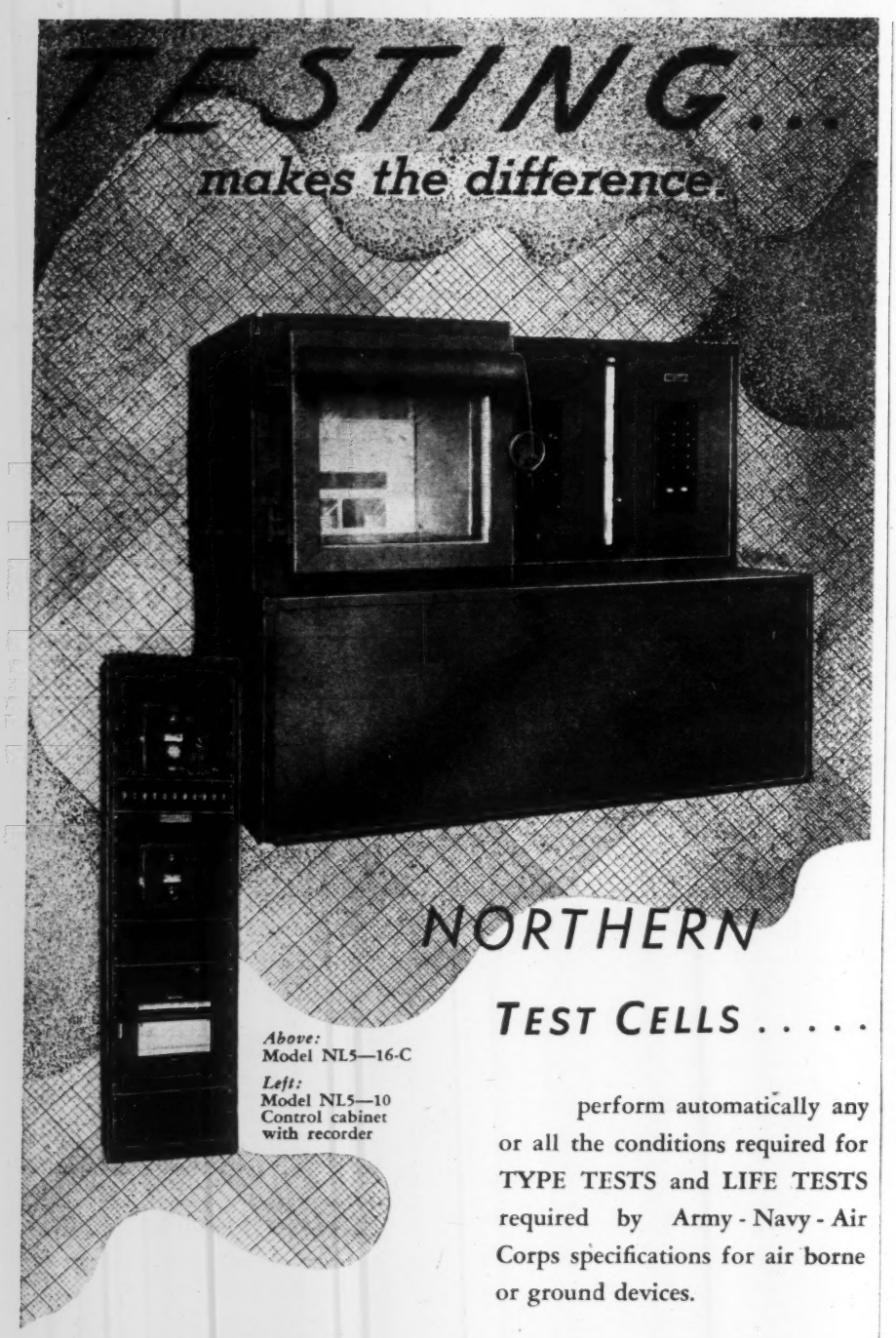

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Model NL5—16-C

Left:
Model NL5—10
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blue color formed is compared with standards. This gives total phosphate content. A determination on the cold sample (no boiling) gives the ortho present in sample. The difference is the poly phate. Outfit consists of a comparison containing 8 standards, 0, 0.5, 1, 2, 4, 6, 10 ppm, 2 comparison tubes, funnel, paper, graduate, flask and reagenet. equipment is contained in a wooden ing case 9¼" long, 6¼" wide and 9" —*W. A. Taylor & Co., 7300 York Road, timore 4, Md.*

Diamond-penetrator Set for Hardness Testers

New "Master Diamond Checking Set," checking accuracy of hardness-testing ment, can be used on all Clark Hard Testers and other instruments used Rockwell testing. Set consists of a

plated diamond penetrator and two blocks. Penetrator is carefully made to ceedingly close tolerances, is designed be used only for checking purposes. Wh checking, "master" diamond penetrator places the regular penetrator in machi The same is true of the two master blocks: held to extremely close limits, th are used only in connection with the mast diamond. The resulting combination is s to furnish accurate check of machine eith as a periodical measure or whenever rea ings may be in doubt. New set is furnish ready for use in a fitted case.—*Clark Inst ment, Inc., 10200 Ford Road, Dearbo Mich.*

Transportable A-c. Test Sets

Three new a-c. test sets mounted three-wheeled trucks so they can be eas moved about and plugged into convenie a-c. outlets, and capable of supplyi

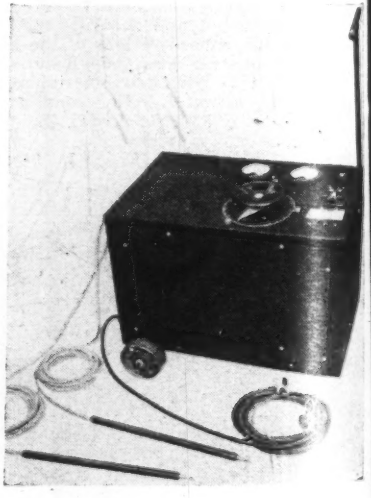

Fig. 1

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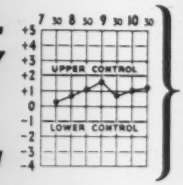
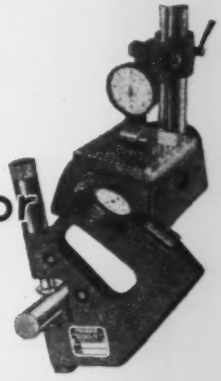


+ { FEDERAL Dial Indicator Gages



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smooth test voltages from 0 to maximum rated voltages (2000, 6000 and 1500 volts), have been announced. Each will find many industrial testing applications such as generators, motors, motor parts, etc.

2000-volt and 6000-volt Sets.—These are similar enough to be described together. Fig. 1 shows the 2000-volt set. Both operate from any 115-volt, 50- or 60-cycle outlet. Both have a capacity of 2000 volt-amperes. Each consists of a dry-type step-up transformer, variable-voltage autotransformer, two indicating voltmeters, voltmeter selector switch, signal lamp, air circuit breaker with magnetic overload trip, and a supply switch. Two 15-ft. shielded test leads with insulated handles and a 15-ft supply cord with plug are also included. One of the indicating voltmeters is used to measure voltages up to half of maximum rating; the other up to full test voltage. This assures accuracy of results and eliminates guesswork, even when testing at relatively low voltages. Rectangular steel cases are mounted on three-wheel trucks and grounded through third conductor in supply lead. When sets are not in use, the three leads are coiled and hung on hooks attached to rear panel of case. Handle remains in a vertical position when not in use. Both sets are 19" high. The 2000-volt unit is 18" wide and 22" long, weighs 290 lbs.; the 6000-volt set is 15" by 25" and weighs 325 lbs.

15,000-volt Set (Fig. 2) is relatively small 30"×49"×36" high) for its capacity of 5000 volt-amperes and is said to be suitable for "highly accurate testing" of large motors of approx. 1500 hp., transformers up to several thousand kva, insulators and other pole-line hardware, etc. Complete equipment consists of a step-up transformer, built-in electric timing clock, double-scale switchboard-type voltmeter for full-range accuracy, voltmeter scale selector switch, air circuit breaker with instantaneous overload trip, built in a crackle-black enameled case

Fig. 2

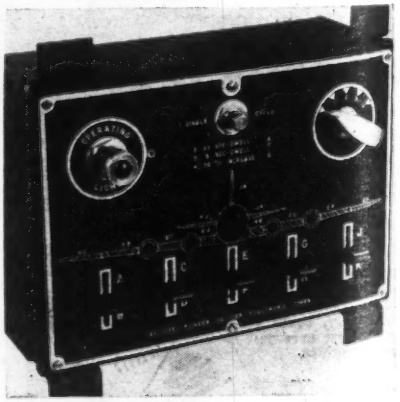
enclosing all energized parts. A 15-ft. supply cord and plug, and two 15-ft. shielded high-voltage leads with insulated test handles are also included. All controls (except safety foot-switch that shuts off high voltage when released) are mounted on an inclined control panel facilitating operation of set from either a standing or seated position.—*General Electric Co., Schenectady, N. Y.*

Lens-cleaning Tissue

New lens cleaning tissue being introduced to industrial and technical fields is a soft, silky linen tissue, specially prepared for cleaning fine optical and precision mechanical instruments without danger of injury to delicate parts. Tissues are processed for tensile strength and absorption qualities and "under all types of rigid tests" have cleaned optical surfaces and precision parts without scratching or leaving trace of lint, regardless of amount of cleaning and rubbing done. New tissues are available in 10" rolls, 500 feet long and in sizes 4" × 6", 6" × 8", 8" × 12", 12" × 12", 1,000 sheets to a box.—*Superfine Lens Cleaner Co., 37 W. 20th St., New York 11, N. Y.*

Electrical De-icer Timer

New "Electronic De-Icer Timer" is designed in accordance with physical principle that to effect complete ice removal by de-icer method, accretion of ice must be permitted to develop a tensile strength sufficient to overcome adhesion between ice and inflated boot. Accordingly, for effective ice removal, de-icer system must be controlled for both rate of accretion and texture of ice formation. New timer is designed for use in conjunction with "Manifold-Solenoid De-Icer System," and provides automatic or manual remote electrical control of de-icer boot operation, automatically opening the



TRERICE

THERMOMETERS

No. A1240 2½ Industrial | No. M81110 Dial | No. M82115 Recording

TEMPERATURE CONTROLLERS

No. 90000 Self-Operating | No. V85002 Air-Operated Non-Indicating Type | No. M87000 Air-Operated Recording

PRESSURE GAUGES

No. 800 Steel Case | No. 600 Iron Case | No. 730 Hydraulic

Write for Catalog 101-G

H.O. TRERICE CO.

Manufacturers of Temperature Instruments

1420 W. LAFAYETTE BLVD.
DETROIT 16, MICHIGAN

Interval Timers

Process Timers

Signal Timers

Time Switches

Relays

Write

AUTOMATIC
ELECTRIC
MANUFACTURING CO.
MANKATO, MINNESOTA

HEAR SEE FEEL

Sensory TORQUE WRENCH

Reflex Torque Control by sight, sound and feel—automatically fast, involuntarily accurate.

Set to desired torque in a few seconds—no further adjustments.

No wearing or moving parts in measuring element—no gears, levers, glass dials or fragile mechanisms.

***Permanently Accurate* Torque Wrenches—with automatically accurate operation.**

STURTEVANT

Write for Bulletin No. S.W. 13

31 Capacities—ranges from 0-8 inch ounces to 0-7200 inch pounds.

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

To the Instrument Man With IDEAS

IF you have designs or patents for post-war production and sales, the Post - War Product Service of The Instruments Publishing Company will gladly put you in touch with interested companies manufacturing instruments and devices for measurement, inspection, testing and control.

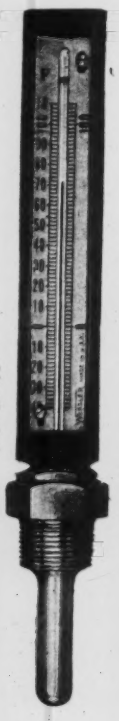
Write to Post-War Products Service, Instruments Publishing Company, Pittsburgh 12, Penna., giving a brief description of your idea, so that this Service may refer it to the interested companies.

This is not the advertisement of any manufacturer or group of manufacturers, but a notice from The Instruments Publishing Company as a service to its subscribers and advertisers. There will be NO CHARGE to the engineer offering the idea or to the company receiving the leads.

INSTRUMENTS FOR INDUSTRY

Weksler Submarines

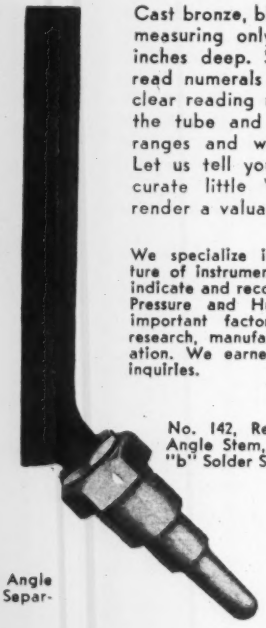
WEKSLER SUBMARINE THERMOMETERS, as their name implies, are compactly designed, ruggedly constructed, highly efficient instruments that take up very little space in their application. Built to strict U. S. Navy specifications, these highly accurate and durable little thermometers should prove extremely useful in many industrial uses.



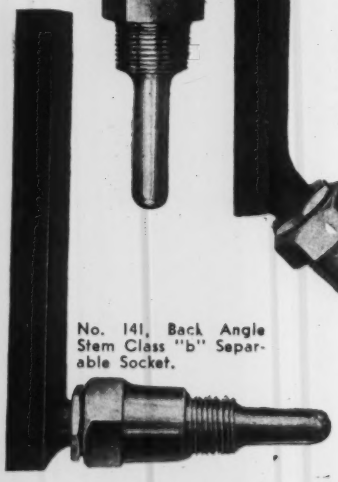
No. 140, Straight Stem, Class "a" Separable Socket.

Cast bronze, black oxidized, "V" shape case measuring only 1⅛ inch wide by 6-9/16 inches deep. Silvered scale with easy-to-read numerals and divisions. A removable clear reading non-breakable front protects the tube and scale. Supplied in various ranges and with stem angles illustrated. Let us tell you how these tough and accurate little Weksler Thermometers can render a valuable service in *your* industry!

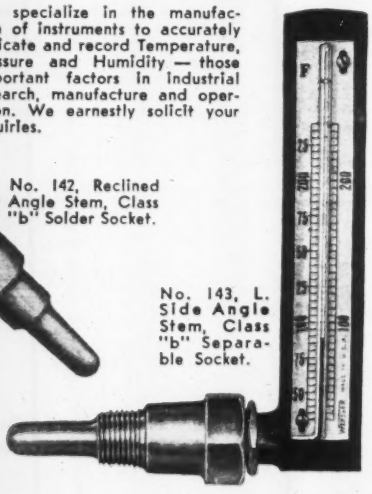
We specialize in the manufacture of instruments to accurately indicate and record Temperature, Pressure and Humidity — those important factors in industrial research, manufacture and operation. We earnestly solicit your inquiries.



No. 142, Reclined Angle Stem, Class "b" Solder Socket.



No. 141, Back Angle Stem Class "b" Separable Socket.



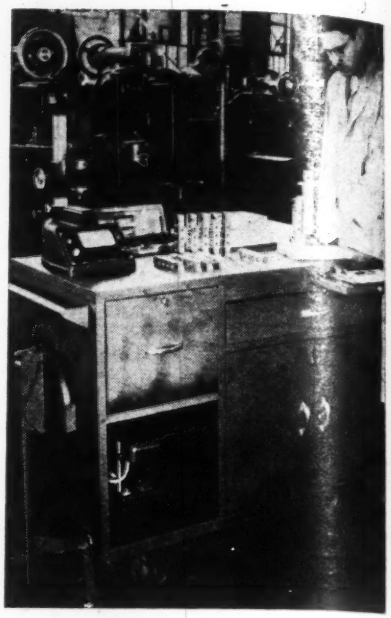
No. 143, L. Side Angle Stem, Class "b" Separable Socket.

WEKSLER THERMOMETER CORP.
52-56 West Houston Street
NEW YORK 12, NEW YORK

boot-inflating valves in proper sequence and for effective time intervals. Control of de-icer system for very light icing, light to moderate icing, severe icing and high-altitude conditions is successfully accomplished. Although new timer is primarily designed for new aircraft, any manifold-solenoid de-icer system now using "Eclipse Mechanical Timer" can be quickly converted to "Electronic" de-icer timer and the mechanical timer eliminated, by merely changing AN connector on existing cable. New timer will function, without adustment, for more than 1,000 hours of icing time. It can be wall- or flush-panel-mounted. It may be opened for inspection from front while in operation, or for complete removal from case. Unit measures 8⅞" long, 6⅛" high, 3¾" deep and weighs 6.5 lbs. (a weight saving of 10 lbs. over previous unit).—*Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.*

Transportable Gage-inspection Laboratory

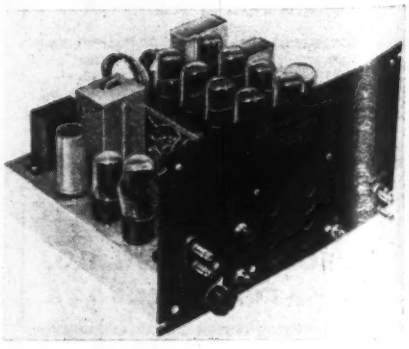
New "DoALL Mobile Inspection Unit" occupies 7 sq. ft. of floor space, is wheeled to the point of work, contains all the necessary instruments and gages of an inspection department. Optical flat and monochromatic light are its basic standards. Set of eighty-three precision gage blocks provide accuracy in height, flatness and parallelism to ± 4 microinches. Set of twenty different precision measuring instruments includes calipers, trammel points, center points, scribers, base blocks, gage holders of 2", 6", 9" and 12" capacities, vernier gage block, master square, sine bar, straight edges, master flat and a 12" × 24" precision surface plate. "DoALL" comparator gage (see *Instruments*, Aug. 1944, pages 519-520) has four ranges of magnification, 6½" height gaging



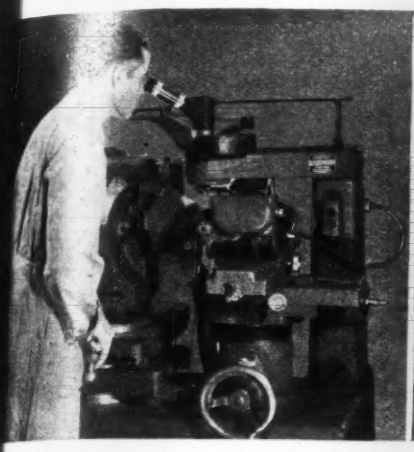
capacity and 4" throat capacity, variable spindle pressures from 8 oz. to 40 oz. An illuminated magnifying glass on a stand is also provided. The accuracy of these instruments is in turn quickly checked by using the optical flats and monochromatic light. New Mobile Unit is of all-steel construction providing a rigid foundation for the working surface which is covered with heavy-duty linoleum. Four rubber-tired heavy-duty caster wheels can be locked so that unit becomes securely anchored when in use. A plug-in-box at back of unit supplies electricity for the monochromatic light, electric comparator and magnifying glass. Unit contains storage space for all precision instruments and gages which are provided; and also ample room for plug gages, sets of wire measuring rods, micrometers and other measuring instruments. Desk drawer has ample space for records. A pull-out desk enables operator to make his notations on the spot. A collapsible chair is also furnished.—*Continental Machines, Inc., 1301 Washington Avenue South, Minneapolis 1, Minn.*

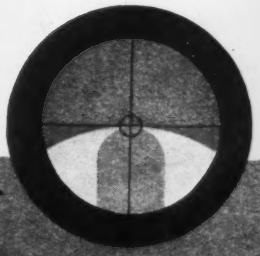
1000-c.p.s. Counter

New two-decade "Electronic Counter," designed for industrial and laboratory uses, is actuated by a closing contact, sine wave, or pulse input, as from a photocell, at rates up to 1,000 c.p.s. Each decade divides by ten, giving a scaling factor of 100. The count for 0 to 99 appears on two banks of neon lamps. A telephone-type relay is connected to counter output and its contacts close once for each 100 input cycles. These contacts are connected to an output terminal. A conventional electromechanical counter may be connected to output terminals to extend count to as many places as desired. Among applications: counting rates exceeding 10 c.p.s. which are general-



The "Eye" of the Sheffield Micro-Form Grinder is a built-in Spencer microscope





HOME FRONT BOMBARDIER

His "sight" a Spencer microscope, the operator of this Sheffield Micro-Form Grinder unerringly guides the abrasive wheel to its mark. Following a master drawing 50 times enlarged, he rapidly cuts profiles—accurate to three ten thousandths of an inch.

Sheffield engineers received the cooperation of Spencer scientists and manufacturing personnel in the design and production of an optical system for this precise work.

To other manufacturers planning products with optical components, Spencer offers a capable research and engineering staff, as well as extensive, up-to-date manufacturing facilities.

Spencer LENS COMPANY
BUFFALO, NEW YORK
SCIENTIFIC INSTRUMENT DIVISION OF
AMERICAN OPTICAL COMPANY

Laboratory Standards

MODEL 62

VACUUM TUBE VOLTMETER

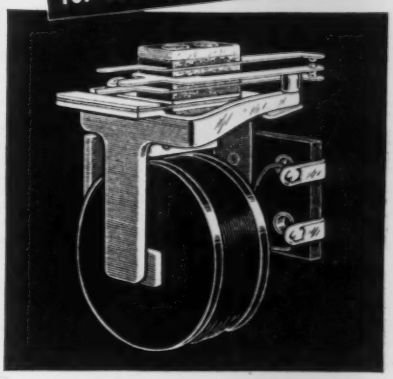
SPECIFICATIONS:

RANGE: Push button selection of five ranges—1, 3, 10, 30 and 100 volts a. c. or d. c.
ACCURACY: 2% of full scale. Useable from 50 cycles to 150 megacycles.
INDICATION: Linear for d. c. and calibrated to indicate r.m.s. values of a sine-wave or 71% of the peak value of a complex wave on a. c.
POWER SUPPLY: 115 volts, 40-60 cycles—no batteries.
DIMENSIONS: 4¾" wide, 6" high, and 8½" deep. **WEIGHT:** Approximately 6 lbs.
PRICE: $135.00 f.o.b. Boonton, N. J. Immediate Delivery

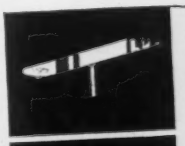
MEASUREMENTS CORPORATION
BOONTON, NEW JERSEY

CLARE

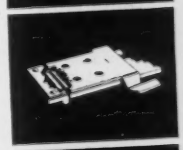
Type "400" Relay
for 400 Cycle A.C. Operation



Clare Type "400" Relay is a fast operate, fast release relay originally designed to operate from a 400 cycle aircraft power supply. It is unusually small, light weight, and withstands vibration. Like all Clare Relays, Type "400" is "custom-built" to meet the requirements of many special applications. Operating time is from .001 to .005 seconds; release time from .002 to .010 seconds. The special reed type armature bearing is made of heat-treated beryllium copper, which is practically fatigueless, making anti-vibration springs unnecessary. Type "400" is available for voltages from 12 to 120 volts, 300 to 500 cycles. Special features, shown below, make Type "400" well adapted for applications in the design of fine instruments.

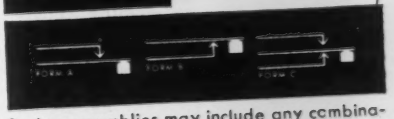


Strong, hard, long wearing bakelite bushing insulators resist vibration and heavy contact pressures.



Hinge of "fatigueless" beryllium copper insures long life and accurate performance under vibration.

Contacts are welded to nickel silver springs by special process.



Spring assemblies may include any combination of these basic forms.

Let Clare engineers "custom-build" the Type "400" to meet your specifications. Send for catalog and data book. Address C. P. Clare & Co., 4719 Sunnyside Avenue, Chicago 30, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays
for Electrical, Electronic and Industrial Use

Ingenious New Technical Methods

Presented in the hope that they will prove interesting and useful to you.

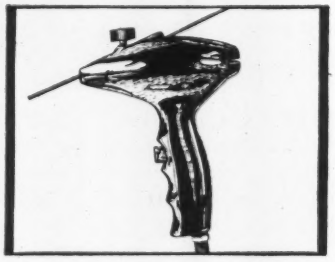
Highly Versatile "Pencil Weld Gun" Welds Cold... Corrects Flaws and Defects ... Saves Man Hours, Materials

The Pencil Weld Gun, used with its Vibra-Weld Transformer, offers simplicity and versatility never before known in the industry. Equally effective in correcting flaws and defects in both ferrous and non-ferrous metals—for welding cold, without setting up stresses or crystallization.

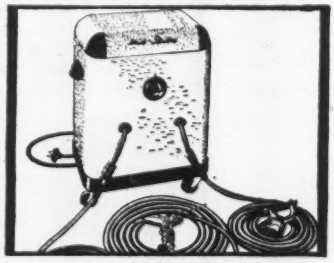
Simple in Operation, the Pencil Weld Gun requires but a few moments' practice to achieve results formerly unobtainable with any method. Utilizing a combination of air, high amperage and low voltage, the weld never exceeds 125° to 130° F. The gun uses a pure aluminum or nickel rod, which is applied directly to the defective area. When the surface has been finished and polished off, it is impossible to detect the repair. Easy to use, as gun peens and welds simultaneously. The Pencil Weld Gun and Vibra-Weld Transformer can be used wherever 220 volt single phase electricity and air outlets are available.

Unavailable, however, is Wrigley's Spearmint Gum. As the makers of Wrigley's Spearmint are unable to continue manufacture of the product up to their quality standards under present conditions, the only unqualified protection they can give to the consumer and the dealer alike is to keep the Wrigley's Spearmint wrapper empty. While they advertise this empty wrapper, none is being made and any found on the market is old production of a perishable product.

You can get complete information from
Mid-States Equipment Company
2429 South Michigan Avenue, Chicago 16, Illinois



Close-up of new Pencil Weld Gun



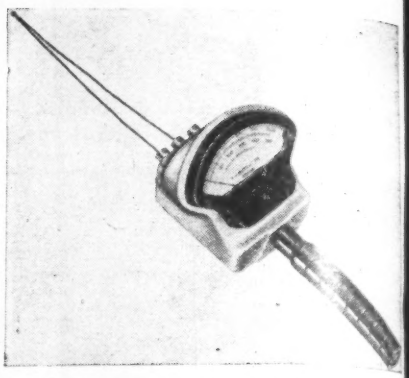
Pencil Weld Gun with Vibra-Weld Transformer

Z-66

ly too fast for conventional counters; or counting and calibrating actual number of cycles that resistance welding timers apply; or in installations where a conventional counter wears out prematurely from high speed continuous operation. New counter makes it possible to increase counting rate 100 times. It can be used as an interval timer by connecting it through a switch to a known external frequency. When switch is closed and opened, unit will count number of cycles of known frequency that have passed in the closed-switched time interval, giving a reading in terms of number of cycles of known frequency. 60-cycle line may be used as known frequency. Equipment is built for rigorous and long use. It uses a complement of 11 tubes. Counter can be supplied with switches to make it predetermining. Operation is from 60-cycle 105 to 125-volt line. Weight is 25 lbs.—*Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.*

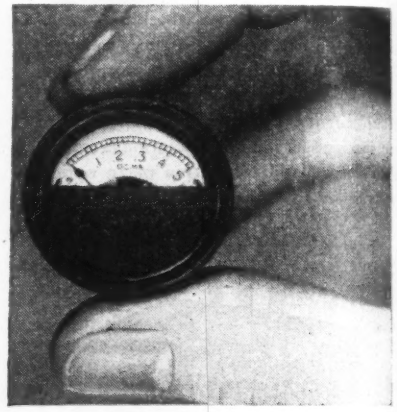
Portable Pyrometer

New portable pyrometer, weighing 1¾ lbs. and said to offer revolutionary design features, is particularly adapted to reading temperature of molten metals (exclusive of ferrous metals), hot air or liquids and for hot surfaces, if used with prod type thermocouple. Scale is said to offer maximum reading ease in all working positions and also to minimize side reflections on scale glass. This unusual shape further lessens risk of scale glass coming in contact with other objects when instrument is placed in any resting position, therefore reducing glass breakage. Instrument movement is accurate to 2% of scale range. Dual scale is standard with readings of: 0 to 500°F. and 0° to 1000°F.; 0 to 750°F. and 0° to 1500°F.; or, 0° to 1000°F. and 0 to 2000°F., or equivalent °C. Other scales are available on special request. Manual room temperature adjustment can be made by the zero adjustment screw on face of indicator. Sturdy 6" handle permits firm, comfortable grip and exceptionally light weight of instrument minimizes wrist and arm fatigue.—*Instrument Div., K. H. Huppert Co. 6830 Cottage Grove Ave., Chicago, Ill.*



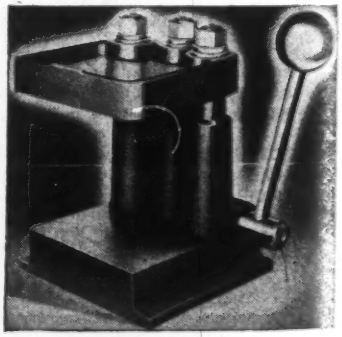
Miniature Electrical Indicating Instruments

New complete line of 1" diameter voltmeters, ammeters, milliammeters and microammeters weighing 1¼ ounces has been developed for aircraft use. These moving-coil type instruments are hermetically sealed in a rugged anodized aluminum case which also has provision for hermetically sealing instrument case to mounting panel. As a companion-instrument to the one-inch round, there is also announced a 1½" round of the same type case construction, weighing 1½ ounces. Both the 1" and the 1½" find a multitude of applications in the aircraft and portable equipment fields where size and weight are of prime importance.—*Dep't. S, MB Mfg. Co., Inc., Instrument Div., 250 Dodge Ave., East Haven, 12, Conn.*



Clamping Jig

New "Cone-Lok" clamping jig is of rugged construction, exceptionally safe in operation, versatile, and possesses a minimum of moving parts. It utilizes braking power of



Running Time Meters
(Panel Mounting)

•3½" Bakelite Case. Built to meet exacting Government standards. Now available for immediate delivery. Several exclusive features that insure peak performance and ease of installation. Write or wire for sample and interesting competitive prices.

Sample Meter Sent on Request

IMMEDIATE DELIVERY

Exclusive Sales Agents
Sales Engineering Associates, Inc.
3907 San Fernando Road • Glendale 4, Calif.

WHAT do you need in a PYROMETER ?

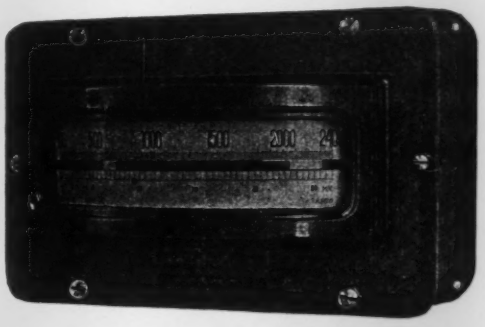
SENSITIVITY RESISTANCE
DURABILITY SIMPLICITY

Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

Write for Catalog

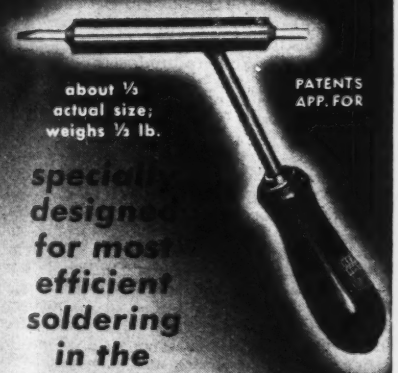
PORTABLE MODEL P-1

WALL TYPE W-1



CHARLES ENGELHARD, INCORPORATED
90 CHESTNUT ST. NEWARK, NEW JERSEY

The IMPROVED
KELNOR
REG. U. S. PAT. OFF.
electric SOLDERING IRON



specially designed for most efficient soldering in the
ELECTRONIC, RADIO AND INSTRUMENT manufacturing and repairing fields

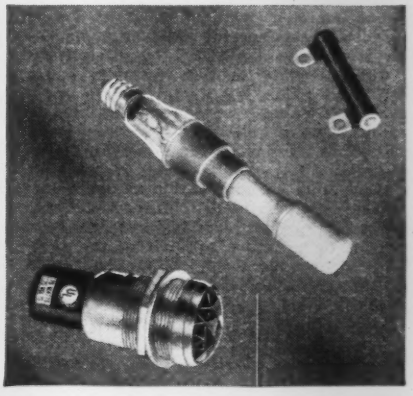
Easily solders hard-to-reach connections. Cuts down fatigue, increases accuracy.

ORDER FROM YOUR JOBBER, OR DIRECT.
GENERAL OFFICES: CENTRAL TOWER, SAN FRANCISCO 3

KELNOR MANUFACTURING COMPANY

CONSIDER THE NEW DRAKE No. 75 AP
Underwriters Approved!

TRADE demand has caused Drake to produce this new totally enclosed candelabra screw base 1" pilot light assembly. The unit is approved by the underwriter's laboratories for 75 watt, 125 volt service. Designed to house the Mazda S6, 110 volt, 6 watt candelabra screw base lamp. Can be supplied with lamp installed. The unit mounts in a 1" hole and is regularly furnished with a 1" diameter faceted colored glass jewel. It is also supplied with a steel lock washer which holds the unit firmly to the panel. Mounts on any thickness panel up to ½".



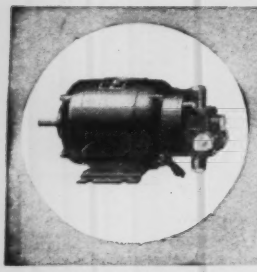
Although designed to operate on 110 volt circuits, this assembly can readily be used on 220 volt circuits by connecting our No. 116 wire wound resistor in series with the pilot light.

Lamps are easily removed with our S6 lamp remover. Anyone who has to maintain, or install in production, large numbers of S6 lamps, will find the S6 lamp remover a great convenience.

DRAKE

SOCKET AND JEWEL LIGHT ASSEMBLIES

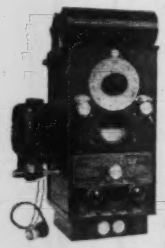
DRAKE MANUFACTURING CO.
1713 WEST HUBBARD ST., CHICAGO 22, U. S. A.



PRECISION MOTORS
for important instrument applications

The Bodine Type N-12R Speed Reducer Motor transmits low torque over a wide range of speeds. It is durable, quiet-running, and dependable. The speed reducer is built integral with the motor.

TYPICAL APPLICATION



Foxboro Temperature Controller used to maintain constant temperature in industrial processes. A small Bodine motor drives the fuel regulating mechanism.

Many complicated industrial processes depend upon instrument control. When the instrument is motor driven, a very important consideration is the dependability of the power unit. Not only must the motor be correct for the application . . . it must be of quality construction to give reliable operation and long service life.

Bodine has manufactured quality fractional horsepower motors for 40 years. Every Bodine motor undergoes severe tests to assure trouble-free performance. Bodine engineers are at your disposal to answer questions of motor selection and application. Bodine Electric Company, 2244 W. Ohio St., Chicago 12, Ill.

BODINE FRACTIONAL HORSEPOWER MOTORS

Post-War Clock Movements
by
CHELSEA

Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile, we would welcome the opportunity of working with you in developing your post-war designs.

Remember, Chelsea has been making special movements for recording instruments for many years.

Buy Another Bond Today

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Vacuum Capacitors

New "I.C.E." vacuum capacitor has been developed to meet a wide range of specifications. In common with other vacuum capacitors these are characterized by compactness and stability, due to utilization of vacuum as the dielectric, but it is said that this is the first time a manufacturer has developed a capacitor meeting varying requirements of capacitances. New capacitor is available in capacitances ranging from 10 to 110 micromicrofarads in steps of one micromicrofarad, accurate within $\pm$ 1 $\mu\mu$fd. A special grade of I.C.E. Vacuum Capacitors is also available offering tolerances held to 0.1 $\mu\mu$fd. Thus it is now possible to secure various grades of vacuum capacitors with capacitance values other than the conventional models.—*Industrial and Commercial Electronics, Belmont, Calif.*

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New "Type CM" insulated resistors are integrally molded in one operation under laboratory controlled production standards, have been specifically designed to meet recently-issued Army-Navy specifications. New units are available in ½-watt (RC-10); ½-watt (RC-21); and 1-watt (RC-30) sizes in all required ranges. Their construction is said to be such that they offer an exceptional degree of stability under load, average change being less than 5% after 1000 hours under test at full load. In addition to having highly satisfactory humidity characteristics well within today's exacting requirements, new insulated resistors meet up-to-the-minute salt water immersion specifications.—*Stackpole Carbon Co., St. Marys, Pa.*

Instruments' Book Shelf

INTRODUCTION TO CIRCUIT ANALYSIS. By A. R. KNIGHT and G. H. FETT. Harper & Brothers, New York, 1943. Cloth, 6 × 9 inches. 447 pages. Price $4.00.

A book of fascinatingly practical scope, both for the student and practicing engineer, written in a style which combines an enviable method of approach to difficult material, with a brief cogent mathematical description of phenomena, important to electrical circuit analysis. Professors Knight and Fett begin their preface: "to the Student," with the highly significant statement, "The student is apt to become lost in circuit theory, because of the mathematics which must be used. He should recognize that mathematics is to be used as a convenient tool and a convenient language in which to express his ideas accurately and concisely, but that it is not an end in itself;" and further, "There are only a few basic laws, based upon experimental evidence which must be applied to the circuit problem. These are: Ampere's, Coulomb's, Faraday's, Joule's, Kirchhoff's, Ohm's, and the Law of the Conservation of Energy." A more concise and significantly arranged assembly of basic background knowledge could not, in the opinion of the reviewer, be chosen for a proper sequential study program.

In evaluating a book, it is perhaps of importance to be able to understand the aim and purpose of the authors; and thus the volume reflects constantly the newer educational approach to teaching circuit analysis. Such major portions of an engineering course as Magnetostatics, Electrostatics and Electrodynamics, are conceived as specific applications of generalized Kirchhoff's Laws rather than segregating Direct-current, Magnetic, and Alternating-current circuits into separate groups, as is more typical of preceding educational methods. The whole tenor of the book is drawn toward analyzing an electrical problem, not as an opportunity to substitute numbers in a formula from which one obtains a ready answer, but rather as methods as to how a problem may be broken down into its component parts; then exploring the various means of attack in terms of known laws to allow choosing the most expeditious. Finally, the solution is obtainable by the application of these fundamentals in accordance with the method or methods chosen. It becomes obvious, therefore, that the student must acquire a mental discipline which enables him to analyze, and eventually choose, those simple weapons, which clarify the attack upon the problem.

Although circuit analysis may normally present a picture of formidable proportion to the prospective student, this volume assumes no such aspects, since it is not a formal treatise on circuit theory but a beautifully disciplined index to both conventional and unconventional methods of problem solu-

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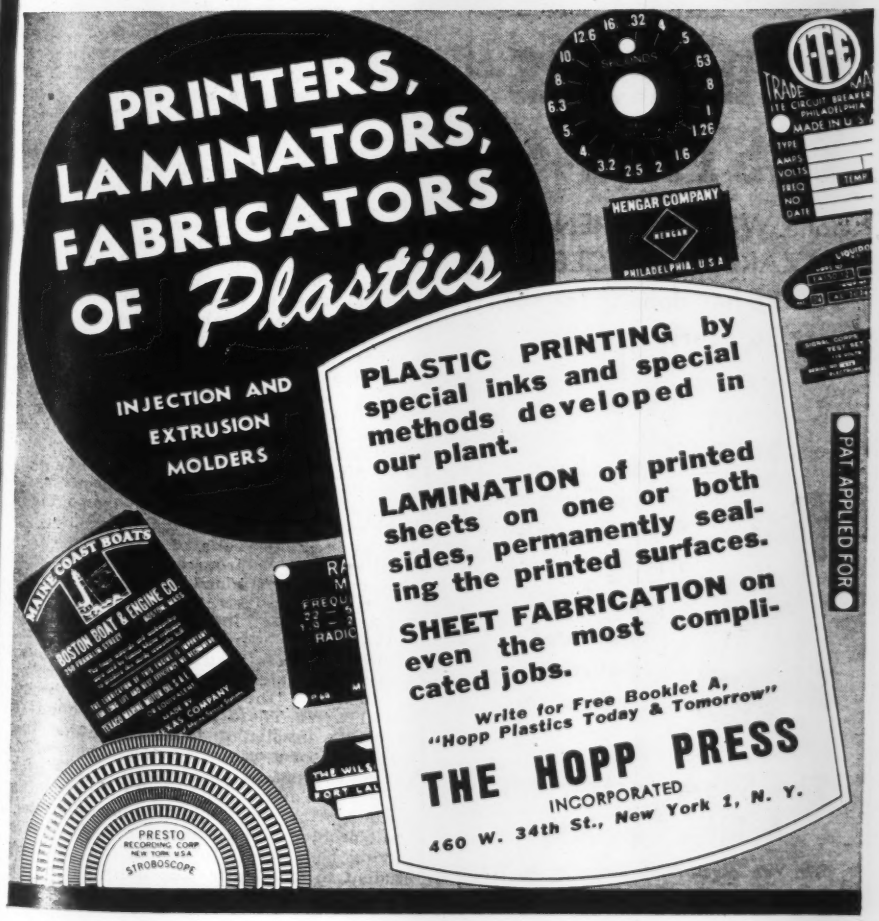
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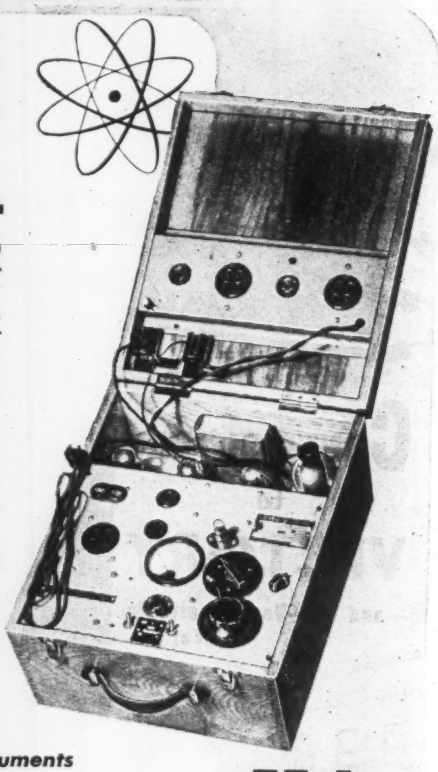

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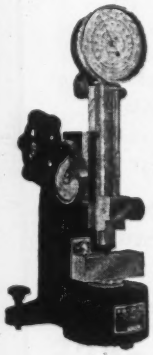

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tions in the entire field of Electrical Engineering.

As an illustration of the brilliant material exposition, one finds such statements as, "There are in general three phenomena present in a circuit. First, there is a cause for the circuit behaviors, such as a mechanical force, an electromotive force, etc. Second, there is an effect produced in the circuit, such as motion, current flow; etc., and, third, there is the opposition offered by the circuit such as friction, resistance, etc., which limits or modifies the effect produced by a given cause."

Inferentially, therefore, a material mechanism, or a circuit (both fundamentally the same kind of critter!) must possess opposition to a causal phenomenon; otherwise, a finite cause would have an infinite effect. With such broad definitions, a large variety of problems in other engineering fields can become subdivisions of circuit analysis. Satisfactory solutions to problems in Dynamics, Mechanics, etc., may be had by applying the analytical powers obtained through study of the written material. Although the described methods are designed for application to electrical and magnetic circuits, a little ingenuity on the part of the student will enable him to apply them to a variety of problems in non-electrical technical fields.

The authors, realizing the importance to the student of a clear understanding of measurement units and unit systems, have devoted considerable space to a brief history of the earlier CGS system with a succeeding exposition of the newer Giorgi MKS system and its rational application. Included tables incorporating conversion factors enable the student to convert expeditiously between CGS, practical units, and MKS units. This portion of the work is rightly placed in the introduction, together with a well-conceived table describing circuit types, ranging from mechanical through thermal to magnetic, and expounding as one of the tabular arguments causatives in such circuits, oppositions in such circuits, and resultant effects in such circuits. The authors furthermore point out the importance of using consistent sets of units in given equations to insure rational answers in the unit system chosen. With considerable forethought, the first five chapters of the book provide a basic understanding of the fundamental electrical and magnetic laws necessary to insure a firm background for circuit study, while strengthening the electrical and magnetic knowledge that the student has absorbed in earlier academic work. These five chapters, however, are written so clearly that it would be possible with little earlier preparation (except for some cursory reading on the student's part) to embark almost immediately upon following advanced work. With little tendency toward over-simplification and yet with no attempt at ponderous and rigorous mathematical treatment, Coulomb's Law as a basic in Magnetostatics is thoroughly covered, leaving the student with a clear understanding of the applications of the law. Ampere's, Faraday's and Kirchhoff's Laws are interestingly expounded in a following chapter, with the same non-rigorous mathematical treatment, and yet with thoroughness sufficient to enable the student to apply these laws to problems involving magnetism and electromagnetics.

A most valuable portion of the book is the basic applications of Kirchhoff's Laws to magnetic, electromagnetic, and current flow problems. Studded with many worked-out problems illustrating applications, the work becomes of inestimable value.

Each of the chapters includes many problems which have been chosen to provide extensive examples of types that may be encountered in the student's future professional work. These problems call upon the student's intelligent intuition rather than merely his selection of a formula and the substitution of numbers therein. The problems range from simple ones to those that challenge the most capable student. In fact, some problems do not have a correct answer, having been posed to enable the advanced student to develop his ingenuity by searching for a more reasonable solution, and at

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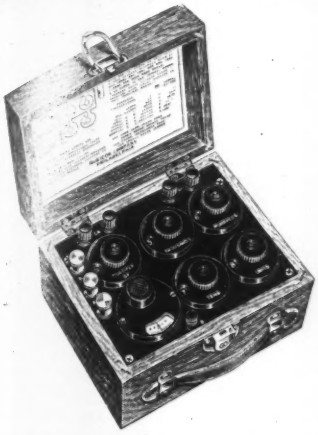

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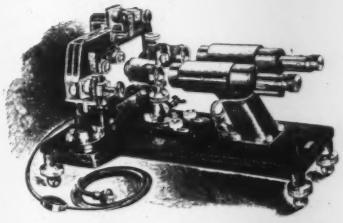

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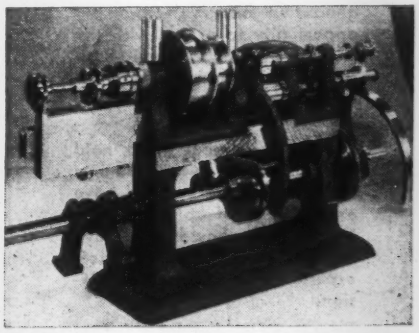

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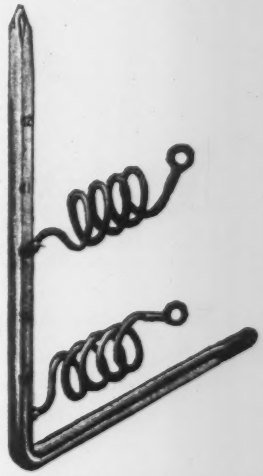

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the same time to experience [illegible] exploratory desire which lies dormant wit[illegible] the embryo scientific engineer.

From the student's standpo[illegible]t, the most significant chapter in the volu[illegible]e is Chapter six, "Step-by-step Solution [illegible]f Circuits." Kirchhoff's Laws are clearly [illegible]lied to various components of a circuit af[illegible] the circuit is broken down, and finally ea[illegible] component is treated separately to arrive [illegible]t a required solution. Graphical methods of [illegible]olution and step-by-step integrations are [illegible]ustrated. The following chapter points out th[illegible] limitations of graphical methods of solu[illegible]n, proceeds to develop methods of attack o[illegible]n an analytical basis, where currents and [illegible]mf's vary as a function of time. Here the [illegible]uthors treat the subject-matter purely on the basis [illegible] a-c. circuits, and have identified d-c. circuits (i.e., circuits where voltage and current do not vary with time) as [illegible]pecial cases of the former. Graphical solutions as a portion of analytical methods are clearly expounded, together with significant trial problems. Vector representation and its relationship to graphical analytical methods are briefly considered.

The application of Kirchhoff's Laws to network problem solution is treated at length in a separate chapter, with emphasis placed upon single- and double-subscript notation. Because of the importance of Maxwell's fictitious current notation in the solution of network problems, considerable space is devoted to this method. The authors with considerable foresight proceed to set up a typical problem and find the solution. Illustrations include setting up equations by single-subscript notation, and solving by method of elimination; setting up equations by double-subscript method and solving by method of substitution; setting up equations by Maxwell's Fictitious Current method and detailed solution by Determinants. Various other methods are illustrated by actual problem work, involving solutions by tabular methods, and use of point equations. The construction of models in network problems is nicely described, while short-cut methods involving the Reciprocal, Thévenin and Norton Theorems are illustrated. Polyphase circuits and their problem solutions are dealt with in the same lucid style.

The volume is terminated by a well-arranged cross index, which, considering the breadth of the included material, should be expanded. Bibliographical references are in the form of footnotes in the various chapters. The printing and general format leave little to be desired from the standpoint of legibility, while the paper stock is remarkably good, considering present-day Government restrictions. A detailed study of the book reveals the searching editing to which the work has been subjected, only a few typographical errors being noted. This book is a classic in scope, and should be present on the bookshelf of every technician.

—THEODORE A. COHEN, *Vice-Pres. Engineering and Research, Wheelco Instruments Co., Chicago.*

1944-45 CHEMICAL ENGINEERING CATALOG. 29th Annual Edition. Reinhold Publishing Corp., New York. Cloth, 8½ X 11 inches, 1581 pages. Price $3.00.

It may seem to some of our readers that this book, now in its twenty-ninth edition, does not require notice in this space. Nevertheless, there are two aspects of importance which justify its mention. Both of these depend on its size and its content. There are 1581 pages divided as follows: Alphabetical index of firms, 3 pages; trade name index, 17 pages; classified index of equipment and supplies, 57 pages; listing of equipment and supplies, 1356 pages; classified index of chemicals and materials, 24 pages; listing of chemical and raw materials, 10[illegible] pages; listing of technical and scientific books, 20 pages.

This enumeration shows in a very impressive manner the magnitude of the achievements of chemistry in the United States, and hence, merely on this score, is deserving of mention. —RICHARD [illegible]MBACH

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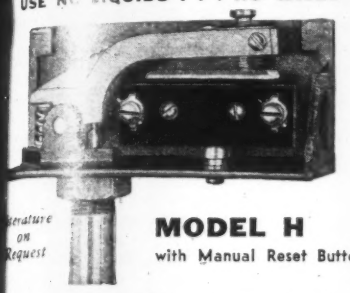

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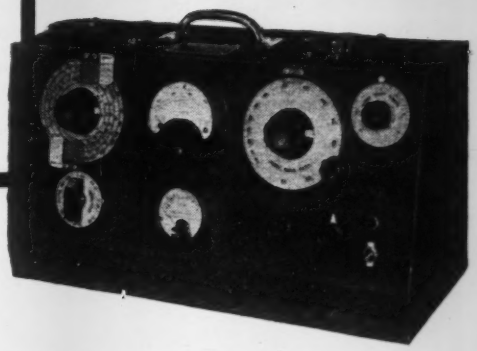

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Instrument Societies

CHICAGO

At the April 2nd meeting of the Chicago Society for Measurement and Control, Mr. Lawrence F. Parachini of the Weston Electrical Instruments Corp., Newark, N. J., delivered an excellent talk on electrical instruments, entitled "Behind the Instrument Dial" and, as the title would indicate, dealing mainly with the construction and operation of electrical instruments.

Mr. Parachini started with the startling statement that modern instruments of the type under discussion are 60,000 times better than those produced some fifty years ago. He stated that better materials and a better knowledge of the fine points of the subject are mainly responsible for this, then proceeded to elaborate.

He first took up the subject of the permanent-magnet pivoted instrument and spoke in detail on the importance of proper winding of the coil; materials used in and construction of the magnet; care in manufacture and polishing the pivots; materials and construction of the springs; materials used for jewels.

An interesting statement regarding instrument jewels was that since the war made it difficult, if not impossible, to get the natural sapphires which previously had been imparted, experiments had shown synthetic sapphires to be superior to natural in a good many respects, and that glass was much superior for certain applications such as aircraft instruments where vibration was an important consideration.

He covered the electrical measurement field quite thoroughly, briefly touching on the moving-iron, dynamometer and hot wire types of instruments, as well as the permanent-magnet type.

Mr. Parachini had a very complete group of demonstration units which he passed around for inspection while he was talking about them. He also asked that any questions be raised at any time during his talk and in this way disposed of questions on one subject before proceeding to the next.

—G. R. THOMASON

KANSAS CITY

At the April 24 meeting of the Kansas City Industrial Instrumentation Society our members enjoyed reading a letter from Leo Burnett, formerly of the Hercules Powder Co. and now FC31-45 USNTS, Lake Union, Seattle, Washington. Leo emphasized the importance of his association with the Kansas City Instrument Society in furthering the training he is now receiving with the compliments of "Uncle." We have acknowledged Leo's letter accordingly, but for the benefit of other members of our society who are now in the armed forces, we would like to have them know that we are still holding all of them on our membership list as Inactive Members. No dues are required and we are going to keep up their subscription to *Instruments* out of our society funds. This was unanimously decided upon by our society as one small way in which we could express our appreciation to former members who are now in the armed forces of our country.

Lester Johnson of Sinclair Refining Co. was the professor of the evening and presented a basic lecture on "Derivation of Orifice Equations." Lester's able explanation of the derivation and similarity of Foxboro, Brown and American Meters Orifice Equations really astounded some of the members.

Our Quiz Kids: Roy Carns (Sinclair Refining), Rhem Benninghoven (Republic Flowmeters) and John D. Marsh (Corn Products Refining) acted as tellers to answer one of the most important questions of the evening, "Are we or are we not going to join the Instrument Society of America?" After the votes were counted, it was found that our members voted in a ratio of 6 to 1 in favor of joining now. The Kids handled the rest of the questions just as easily and proved they couldn't be stumped.

Our guest speaker, A. A. Blackman of the Bristol Co., St. Louis, Missouri, presented a swell lecture on "Time Cycle Control and Application." The slides and illustrations which he showed on the application of time cycle controls to the rubber and tobacco industries, etc., aroused much interest among our members. As Mr. Blackman mentioned, time cycle control is only in its infancy and we will be hearing more and more of it as time goes on.

—W. A. REICHOW, *President*

I. S. A. FORMED
For the report of the formation of the Instrument Society of America
turn to Page 296

LOS ANGELES

The second regular meeting of the California Instrument Society was held in the Green Room of the Chapman Park Hotel, Los Angeles, on Tuesday evening, April 3rd, 1945.

About fifty attended the dinner and around seventy atended the business and technical meeting.

The speaker of the meeting was Mr. Willard C. Bruce, Equipment Maintenance Engineer of the Southern California Telephone Co. His subject was "Subscriber Dialing of Intercity Toll Calls." This is one of the newest developments in telephone communication, and is a system which enables the subscribers to dial their own toll calls to nearby points. The equipment embodies many ingenious applications of instrumentation. It not only performs intricate switching operations, but it automatically prepares a printed ticket which shows the calling and the called numbers and other information needed for charging the call. The only commercial installation of this type of equipment was placed in service last year in Culver City, California.

Mr. Bruce, who is in charge of the operation of this equipment, gave a very complete description of the apparatus, circuit arrangements, and service features of the system.

His talk was illustrated by interesting slides and he had with him several pieces of equipment such as are used in the installation, including relays and switches.

Although organized less than two months, the California Instrument Society has over eighty-five members from a prospect list of over two hundred and fifty who had expressed an interest in the Society.

—M. D. PUGH, *Secretary*

NEW JERSEY

The regular meeting of the Society for Measurement and Control on May 1st at Essex House, Newark, N. J., was attended by 88 members and guests, including visitors from New York and Philadelphia.

Announcement was made as to results of the election of officers for the 1945-1946 season, as follows: *President*—R. F. Roberts; *Vice President*—W. C. Ludi; *Treasurer*—S. Baran; *Secretary*—H. S. Close.

Mr. H. F. Moore rendered a report following his attendance as delegate at the recent intersociety meeting in Pittsburgh, stated that a National Society has now been formed to be known as "The Instrument Society of America," and that pro tem officers had been elected, also committees appointed to proceed with organization and preparation of constitution and by-laws for submittal to all societies for ratification.

The guest speaker of the evening, Dr. C. E. Mason, Technical Director of The Bristol Company, delivered a very instructive and interesting talk on the subject "Influences which Affect Control Valve Characteristics." The talk covered the early history of valve usage in regulation and control, and a practical means of indicating the true controlling qualities in any type of valve flow characteristic. A number of slides were shown, and the blackboard was used extensively to illustrate flow curves and formulae. A lively question and discussion period followed, with several trying to get solutions to specific valve problems, even after the meeting was adjourned.

—H. S. CLOSE, *Secretary*

NEW YORK

Seventy members and guests attended the 27th meeting of the New York Society for Measurement and Control, on March 29, 1945, to hear Dr. W. J. Sweeney and Dr. Robert W. Scott, Research and Development Dept., Standard Oil Development Company, talk on "New Methods of Instrumentation in the Petroleum Industry."

Dr. Sweeney opened the evening by citing the problems of making new products on a mass scale and some of the difficulties involved. Dr. Scott continued the discussion, breaking down the problems into Analysis, Control and Regulation. He illustrated and described the instruments used for each purpose. One of the most interesting points brought out was the comparison of the time required to perform operations with the newer instrument with that required with older methods.

—H. L. HILDENBRAND, *Secretary*

The twenty-eighth meeting of the New York Society was held on April 24th at the Men's Faculty Club, 400 West 117th Street, New York City. The membership present voted unanimously to empower C. O. Fairchild as Delegate and C. F. Kayan as Alternate to attend the meeting in Pittsburgh on April 28th and act for the New York Society in forming the Instrument Society of America.

On behalf of the members, Professor Kayan presented to C. O. Fairchild a gift in recognition of his two years of effort as first President of the New York Society. The gift was a presentation model Waterman fountain pen engraved "C. O. Fairchild, President, New York Society for Measurement and Control, 1943-44."

Mr. Robert W. Mayer, Manager of Industrial Sales, The Kelly-Koett Mfg. Co., Covington, Ky., spoke on "Inspection Application of X-rays." He illustrated his talk with slides and discussed the X-ray and Fluoroscopic inspection problems, the results to be expected and the equipment used.

—H. L. HILDENBRAND, *Secretary*

NORTHERN INDIANA

The Northern Indiana Society for Measurement and Control met Friday, April 20 at the Lake Hotel in Gary.

John Beam was Technical Chairman for the meeting and introduced Mr. J. J. Connelly of the Cities Service Oil Company, who spoke on Oil Refinery Instrumentation.

Mr. Connelly spoke on refinery instruments in general. Using a large diagram of a still, he traced the process through and explained the instrumentation as it controlled the process. The instrument air supply system, interlocking control and instrument maintenance were discussed in very lively fashion. Many ideas and solu-

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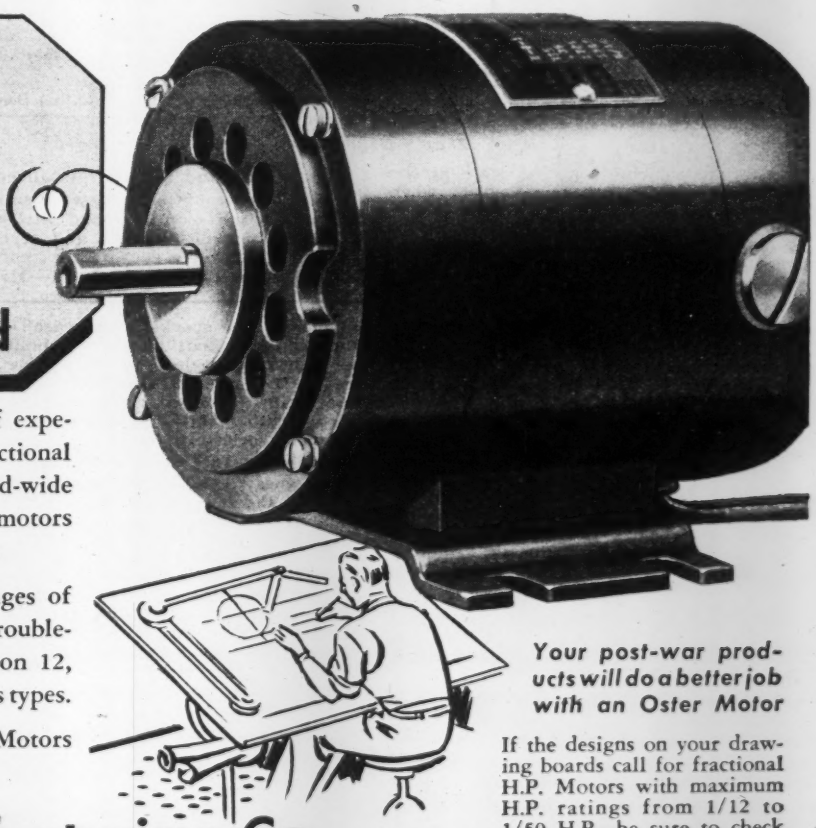

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INSTRUMENT SOCIETIES CALENDAR

City, Society and	Secretary	Date	Place	Subject	Speaker
Atlanta, Georgia — Georgia Society for Measurement & Control	Robert E. Geminert, P.O. Box 1714, Atlanta				
Baltimore, Maryland — Baltimore Industrial Instrumentation Society	J. J. Segleta, 35 S. Potomac St., Baltimore 24		Engineers Club, 6 W. Fayette St., Balto		
Chicago, Illinois — Chicago Society for Measurement & Control	A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago		M&M Club, 237 Merchandise Mart		
Cleveland, Ohio — Cleveland Instrumentation Society	A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3	May 23(B)	Cleveland Engineering Society	Aviation Gas Plant Instruments	Wm. E. Sy[illegible], Standard [illegible] Co.
Detroit, Mich. — Instrument Society of Detroit	Cliff Sackett, Chrysler Eng'g 12800 Oakland Ave. Det't				
Fort Worth, Texas — Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth	May 17(A) June 21(A)	Texas Hotel, Fort Worth Texas Hotel, Fort Worth	Practical Uses of Oscillograph High-frequency Heating	Prof. C. R. [illegible]schmeyer, Rice Inst. J. L. Caudry, Texas Elec.
Gulf Coast (Texas) — Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Texas				
Hartford, Conn. — Hartford Society for Measurement & Control	Gustave L. Manke, c/o Veeder-Root Inc., Sargent & Garden Sts.	May 15(B)	Bond Hotel	Automatic Temperature Control	W. F. Hickey, The Foxboro Co.
Kansas City, Missouri — KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.	May 22(B)	Bluebird Cafeteria	Evolution of the Oil Industry	Repres. of Sinclair Oil Co.
Los Angeles, Calif. — California Instrument Society	M. D. Pugh, 541 South Spring St., Los Angeles, Calif.	June 5(B)	Melody Lane, Los Angeles	Geophysical Sonic Methods in Military Ranging	Richard G. Leitner
Newark, N. J. — Society for Measurement & Control (New Jersey)	H. L. Close, 831 Dixie Lane, Plainfield, N. J.		Essex House		
New York, N. Y. — New York Society for Measurement & Control	H. L. Hildenbrand, 206-07 33d Ave., Bayside, L.I.,N.Y.	May 29(B)	Columbia U. Men's Faculty Club, 400 W. 117th St.	Gas Analysis	Dr. Charles M. Worstall
N. Indiana — Northern Indiana Soc. for Measurement & Control	K. M. Frame, 25 Ruth St. Hammond, Indiana	Apr. 20(B)	Lake Hotel, Gary	Oil Refinery Instruments	J. J. Connelly, Engr. Cities Service Oil Co.
Philadelphia, Pa. — Philadelphia Society for Instrumentation	G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia	May 16(B)	Engineers Club, 1317 Spruce St.	Principles and Applications of Pressure Gages	A. E. LeVan, U. S. Gauge Co.
Pittsburgh, Pa. — American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	May 28(B)	Roosevelt Hotel	Process Control	W. B. Heinz, Cochrane Corp.
St. Louis, Mo. — St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Toronto, Ontario — Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co.	May 17(B)	Diana Sweets, 188 Bloor St. W., Toronto	Industrial Instrumentation	J. N. Franklin
Washington, D. C. — Instrument Society of Washington	W. A. Wildhack, National Bureau of Standards, Wash'n		Interior Dep't Auditorium		
Whiting, Indiana — Whiting Instrument Men's Guild	Lloyd Clouse, 7344 Dante Ave., Chicago 19, Illinois				
Wyandotte, Mich. — Instrument Society of Wayne County	D. J. McCloskey, 116 Oak St., Wyandotte, Mich.	May 28(B)	West Mound Methodist Church	Pneumatic Null Balance System	C. B. Moore, Pres. Moore Products Co.

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no dinner

tions to instrument problems were given; which will be a big help to every one when they have to face them in the future.

In the business meeting, nominations of the officers for 1945-46 were completed. The following by-law was voted into the Regulations and By-Laws.

Section 4—Membership In The Society. Article 3—Associate Membership shall be allowed to persons whose trade or profession entails the utilization of instruments and measuring or control equipment, to teachers, post-graduate students, research workers and employees of instrument manufacturing companies or sales organizations.

The membership voted to become a member of The Instrument Society of America, and send a delegate to the intersociety meeting to be held in Pittsburgh.

—K. M. FRAME, *Secretary*

PITTSBURGH

The April meeting of the American Society for Measurement and Control was held at the Roosevelt Hotel on Monday evening, April 23, 1945.

At the business meeting President R. J. S. Pigott called for nominations for members of a nominating committee. Members elected:

Lester F. Boss, Mellon Institute

M. S. Jacobs, Koppers Company

W. C. Stickney, Gulf Research & Development Co.

Paul G. Exline, chairman of Exhibit Committee, submitted a report on "Instrumentation for Tomorrow" exhibit. Richard Rimbach, chairman of Program Committee announced five speakers for season 1945-46 and requested that members submit possible additional subjects or prospective speakers. A. H. Shafer of The Foxboro Company was again appointed as a delegate to the third meeting of the proposed national instrument society, to be held in Pittsburgh on April 28.

Our guest speaker, Nelson Gildersleeve of General Electric Co., spoke on "Electrical Aids to Chemical Analysis." He used the blackboard to illustrate his lecture beginning with Electromagnetic Spectrum, discussing Spectral Absorption, Infrared Analyzer, Recording Spectrophotometer, Mercury-vapor Detector, X-ray Gas Analyzer, Mass Spectrometer, Acoustic Analyzer, Thermal-gas Analyzer and Dew-point Meters. Several other methods were mentioned but not discussed.

Through the courtesy of Micro Switch Corp., a sound motion picture was shown entitled "Uses Unlimited" featuring Micro-Switches in ships, planes, tanks, trains and motor vehicles, also in control of all kinds of weapons and equipment from large guns and torpedos to the electrical circuits of precision machines.

The dinner preceding the meeting was attended by sixty members and guests, and there were one hundred for the meeting.

—L. M. SUSANY, *Secretary*

Secretaries and Publicity Chairmen!

Keep your group in the news even during the no-meeting months! Send *Instruments* reports of committee work and of delegations to Intersociety conferences; and news items about individual members.—MFB

WYANDOTTE

The Instrument Society of Wayne County met March 26, 1945. The nominating committee for next month's election was appointed.

Mr. Gillig, a member of an instrument society now forming in Detroit, was among our guests.

Mr. Nielson of the Foxboro Co. gave a chalk talk on the new Foxboro Electronic Recorder. We were told of some of the developments we may expect soon in measurement of flow, pressure, temperature, weight, etc. A demonstrator model was set up and arranged to show small variations in temperature and later to show flexures of a steel bar carrying two strain gages.

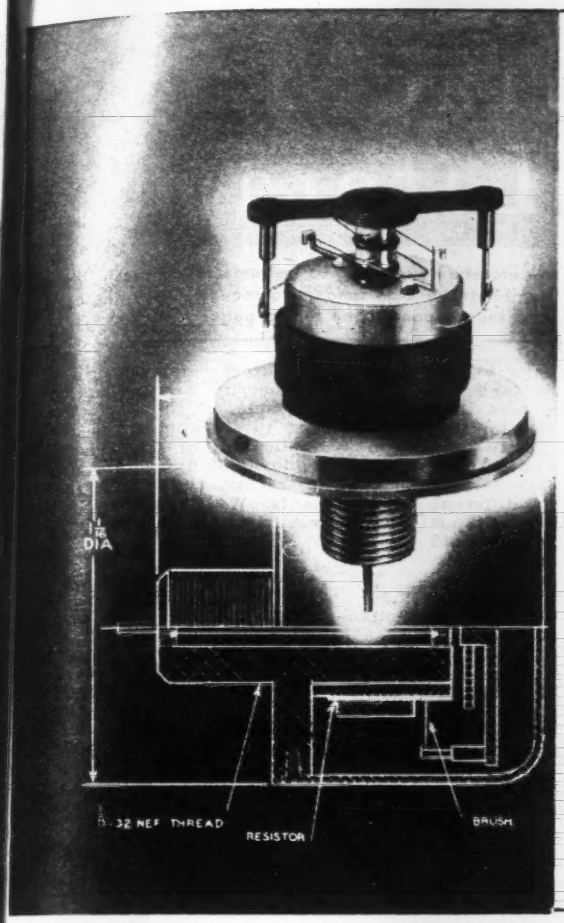
Our group was much interested in the new ideas Mr. Nielson presented and many expressed their appreciation.

—JOHN MACPHERSON, *Vice Pres.*

The Instrument Society of Wayne County met April 23rd, 1945. The annual election was held and the several officers whose terms were expiring were reelected. The Treasurer's report and other reports of the year were read and accepted. A motion was made and passed to instruct our delegate to ask for admission of our group to the Instrument Society of America.

Mr. Art Borden of the Hagan Corporation was the guest speaker. He showed slides and gave explanations of a number of complex control installations including combustion control, desuperheating, paper mill rolls, chemical processes and a dynamometer system. His talk gave us a better understanding of coördinating and interlocking controls.

—JOHN MACPHERSON, *Vice Pres.*



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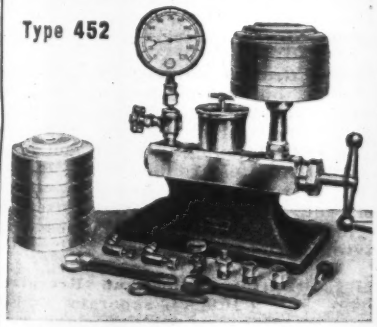

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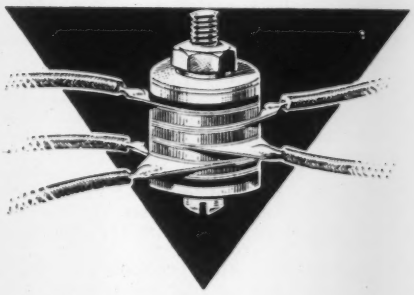

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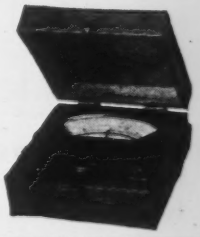

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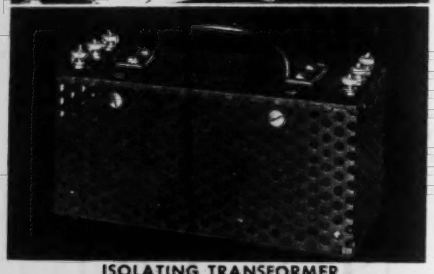

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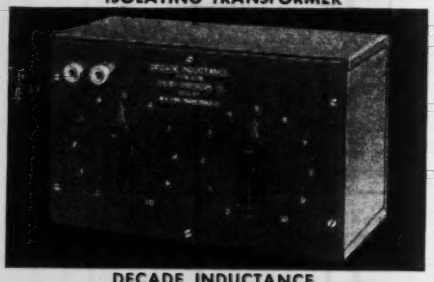
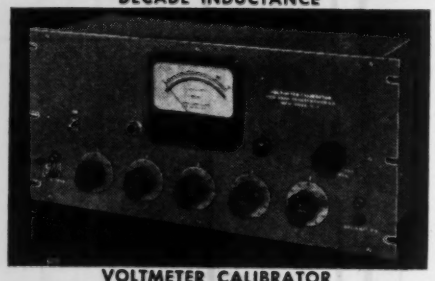


DECADE INDUCTANCE



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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

M-126 **Potentiometers.** 12-page 8½" × 11" Catalog E-33A(2) pictures and describes the White potentiometers. Descriptions cover the single potentiometer for measuring temperature with one thermocouple and the double potentiometer which is equipped with two sets of dials so that thermocouples at different temperatures may be measured without resetting dials. Other accessories and price list are included in catalog. Leeds & Northrup Co., 4911 Stenton Ave., Philadelphia 44, Pa.

M-127 **Kilovoltmeters.** 6-page 8½" × 11" Bulletin "F" pictures and describes portable multi-range self-contained a-c. and d-c. kilovoltmeters. Includes description of external multipliers for use with standard instruments for measurement of potentials up to 25000 volts a.c. or d.c. Bulletin also includes description and photograph of corona protected resistors, price list of equipment and dimensions of cases. Shallcross Mfg. Co., Dept. IS-35, Collingdale, Pa.

M-128 **High-resistance Pyrometer.** 4-page 8½" × 11" Bulletin No. 40 describes "Elematic" self-contained portable pyrometer for checking radio cyrstals, in sub-zero temperatures (—85°C). Instrument has cobalt magnet movement, nickel steel compensator, aluminum pointer and hermatically sealed thermocouple. Also included is a photograph and reproduction of six scale ranges in actual size. Elematic Equipment Corp., 6046 Wentworth Ave., Chicago 21, Ill.

M-129 **Electronic Supplies.** 48-page 5½" × 8½" booklet entitled "April 1945 Availability List" illustrates and catalogs items available on priority for immediate delivery from stock subject to prior sale. Items listed include tubes, test equipment, industrial sound equipment, electrical maintenance supplies, timers, relays, x-ray machines, transformers, rectifiers, demagnetizers, tachometers, etchers, dynamotors, conductivity apparatus, capacitors, flashlight storage batteries, photoelectric units, plastic wiring systems, die-less duplicating tools, drills, saws, and other tools. Price list is also included. Available to engineers and purchasing agents. Walker-Jimieson, Inc., 311 So. Western Ave., Chicago 12, Ill.

M-130 **Dial Indicator Snap Gages.** 4-page 8½" × 11" bulletin pictures and describes light-weight gages of snap gage type for gaging outside diameter of workpieces whether at bench or at the machine. Reference contact adjustable throughout 1" range and is available in three sizes up to 3". Gage permits measurements in recesses or against shoulders not ordinarily accessible with gages of similar types. (Gage is only ⅝" wide) Bulletin also lists thickness gages, outside caliper gages and other snap gages including some with rotating indicator. Federal Products Corp., 1144 Eddy St., Providence 1, Rhode Island.

M-131 **"Westinghouse Newsfront."** 4-page 8½" × 11" April issue of this house organ (First Issue) which describes Company's latest achievements in research, engineering and production, features an article on the Company's annual report to stockholders, a story on a new application of the "Precipitron" for the removal of fly-ash and a picture page illustrating recent Westinghouse developments. Westinghouse Newsfront, 306 Fourth Ave., Box 1017, Pittsburgh 30, Pa.

M-132 **Fathometer.** 4-page 8½" × 11" bulletin pictures and describes a depth sounder which provides instantaneous visual indications of depth from shoal water to 250 fathoms at 48 soundings per minute. First 20 fathoms of scale are marked in booth feet and fathoms. Particularly useful to fishermen in locating fish schools, showing depth to set nets, underwater reefs and landmarks. Also available with chart recorders and soundings of 96 times a minute in waters of less than 250 fathoms. Submarine Signal Co. Adv. Dept., 40 Broad St., Boston, Mass.

M-133 **Multi-range Multi-purpose Test Instruments.** 12-page 8½ "× 11" folder pictures and describes several portable type instruments including industrial circuit tester, volt-ohm-milliammeter, insulation testers, tubecheckers, analyzers, a-c. clamp-ammeter and current transformers. Circuit tester available with 27 ranges. Applications, price list, size and weight, and other accessories are also included. Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark 5, New Jersey.

M-134 **Granite Surface Plates.** 4-page 8½" × 11" bulletin pictures and describes granite surface plates which were inspected and tested by Army and found to be suitable substitute for metal surface plate. Plates are non-magnetic, rustproof, corrosion-proof and temperature-resistant. Available in several sizes. The Herman Stone Co., 324 Harries Bldg., Dayton 2, Ohio.

M-135 **Battery Plug and Receptacle.** 4-page 8¼" × 10½" Temporary Bulletin January 1945 pictures and describes a heavy duty battery plug with two 600-amp. contacts. Plugs are designed with split shell and feature push button for switching on power after engagement. Exploded view of plug and receptacle and specifications are also included. Cannon Electric Development Co., Los Angeles 31, Calif.

M-136 **"The Burrell Technical Announcer."** 16-page 7½" × 8¾" Number 45-3-18 features two articles: (1) Penicillin (reprint from The Glass Packer) and (2) Electro polishing of Steel for Micro Structure by S. R. Prance, Chief Metallurgist, Inland Mfg. Div., G.M.C. Burrell Technical Supply, 1936 Fifth Ave., Pittsburgh 18, Pa.

M-137 **"Paulson's Quick Reference Catalog."** 38-page 8½" × 11" catalog covers a large variety of tools and equipment particularly useful for hobbyists and instrument makers. Over 5,000 items

with illustrations, descriptions and prices. Lacks practical reference and index but lists items in alphabetical order at top of each page. Henry Paulson & Co., 37 S. Wabash Ave., Chicago, Ill.

M-138 **Automatic Weigher-feeder.** 28-page 8¼" × 10½" catalog pictures and describes "Poidometer" feeder-weigher-conveyor which feeds materials by weight in a steady, uniform, constant stream and weighs and registers the total amount of material it handles. Capacities can be varied and proportioned from one pound to 10,000 pounds per minute by "Poidometers" of different sizes each having a wide range of feeds. Suitable for cement industry, clay products, calcium products, feed and grain, food stuffs and minerals. Catalog also includes photograph of several installations, cyclopaedic drawing of poidometer and list of repair parts. Schaffer Poidometer Company, 2818 Smallman St., Pittsburgh, Pa.

M-139 **Motor Selector Guide.** 16-page 7" × 8½" booklet gives a step-by-step method for selecting correct type and size of fractional horsepower motor for a number of applications. Data presented in outline style illustrating comparative characteristics of various types and explains many "built-in" controls. The Dumore Co., Motor Division, Racine, Wis.

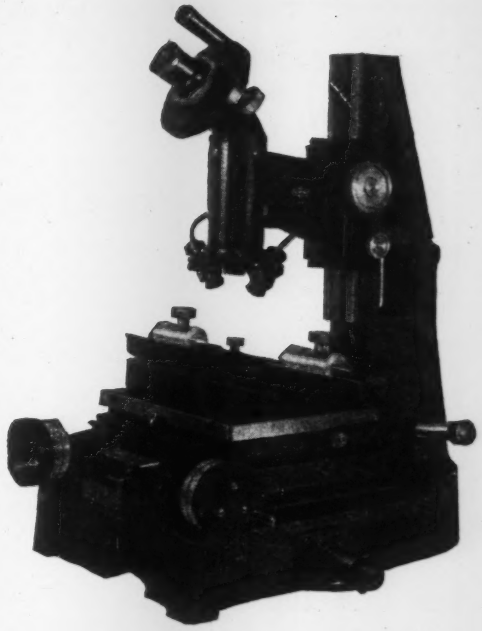
M-140 **"The Ohmite News."** Single-sheet 8½" × 11" February 1945 issue of this house organ features an article on radio transmitters entitled "200-KW Voice of America' Shoots Bullets of Truth." Ohmite Mfg. Co., 4835-41 Flournoy St., Chicago 44, Ill.

M-141 **Power Analyzer.** One-page 8½" × 11" leaflet pictures and describes an analyzer for single-phase, two-phase or three-phase a-c. power measurements. Instrument can measure voltages from 0 to 600 volts, current from ⅓ amp. to 300 amps., watts from 15 to 240 kw, reactive kilovolt amperes and also has phase rotation indicator. Niagara Electrical Instrument Co., 1-7 West Genesee St., Buffalo 2, New York.

M-142 **"How and Why Cathode Ray Tubes Work."** 16-page 8½" × 11" illustrated booklet contains four articles by J. R. Beers reprinted from "Communications" magazine. Author covers (1) Early history of cathode-ray tubes, (2) Manufacturing problems, (3) Testing and (4) Special cathode-ray tube designs. Schematic diagrams, curves, pictorial illustrations and complete television set-ups are used to explain cathode-ray functions. North American Phillips Co. Inc., 100 East 42nd St., New York 17, N. Y.

M-143 **Electronic Resistance Pyrometer.** 12-page 7¾" × 10½" bulletin No. 230-A illustrates and describes Bailey Pyrotron Electronic Resistance Thermometers in indicating, recording and controlling models for temperature ranges between limits of 100°F. and 1200°F. Instrument contains no moving parts in measuring circuit except during temperature changes. Description of electronic detector and motor control, information on ranges, power supply required, speed of response, chart ranges, automatic control application, primary elements, measuring circuits and cut-away sections are also included. Bailey Meter Company, 1041 Ivanhoe Road, Cleveland 10, Ohio.

M-144 **Moisture-content Indicator.** 4-page 8½" × 11" bulletin pictures and describes a portable instrument which electrically determines the moisture content of lumber. Bulletin shows how the electrical field of "Moisture Register" penetrates the material being tested, gives relationship of numerical dial reading to percent moisture content by dry weight and illustrates dial. Instru-



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Instruments, 1117 Wolfendale St., Pittsburgh 12, Pa. *(May 1945)*

Please have the following catalogs, etc., reviewed in this issue sent to me.

Numbers .....

I also desire further information concerning the following new products described in this month's "New Instruments" Department .....

.....

I also desire further information concerning the following products advertised in this issue (Write page number and name of company)

Name .....

Company ..... Position .....

Co.'s Address .....

(OR) Home Address .....